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THE DEVELOPMENT OF ENTOMOLOGY IN NORTH AMERICA.*

By W. J. Holland.

The other day in one of the large astronomical observatories of our country the Director showed me some of the plates, which they are making in collaboration with other observatories, which have united to systematically photograph the whole of the sidereal expanse. The plates showed innumerable little white dots on a black background. The largest of these dots were not bigger than a small fly-speck. "How many suns are there?" I asked. "There are only about five thousand visible to the naked eye in both hemispheres," replied the astronomer, "but with the help of our improved telescopes, reinforced by photography, it is estimated that we can now locate about two millions of suns." "Just about the number of the species of insects, with which we entomologists have to deal," I answered, "and we have the advantage of being able to get at them and dissect them, and learn all about them, while you at the utmost can only learn a little about these stars."

"Natura maxime miranda in minimis."

But my theme this evening is not the vastness of the field of entomological research. When I was requested to address you, I chose as my subject the development of our science in North America.

The first studies of the insect-life of the New World were made by Europeans. We must not overlook the writings of the Spanish chroniclers, in whose pages we occasionally find ref-

* Annual address delivered before the Entomological Society of America, St. Louis, Missouri, December 30, 1919.

erences to the insects of the newly discovered lands. Oviedo as early as 1526 alludes to the abundant and torturing insect pests of the regions which he visited. At a later date Catesby and Sir Hans Sloane attempted an account of some of the species encountered in the Carolinas and the West Indies. Then came the immortal Linnæus and his disciple, Charles Clerck, who about one hundred and sixty years ago began to lay substantial foundations by naming, describing, classifying, and figuring many North American insects. Some of the remnants of the Linnæan Collection are still preserved at Upsala in Sweden, where I had the pleasure a few years ago of examining what is left of them.

Linnæus possessed an encyclopedic mind. His *Systema Naturæ* was a bold attempt to classify all the living organisms of which he had knowledge from the greatest to the smallest. No one of the sciences now comprehended under the great and inclusive term *entomology* but recognizes his influence. All students who make a study of the various orders of insects recognize that the Sage of Upsala was the first to blaze the way into fields, which, as the years have gone by, have seemed ever to expand, and to be more and more filled with wonders.

In the last two decades of the eighteenth and in the early years of the nineteenth century a number of Europeans amplified and extended the labors of Linnæus. The student of North American entomology recognizes his debt to Fabricius, whose writings must still be consulted by systematists. About this time Cramer issued his great work upon the lepidoptera exotic to Europe, the fourth and last volume appearing in 1782, being supplemented by Stoll, whose work appeared from 1787–1791, and who also published important works upon the hemiptera, homoptera, and orthoptera, which the student of today cannot neglect. Smith and Abbot's "Natural History of the Rarer Lepidopterous Insects of Georgia," issued in two folio volumes in 1797, is one of the monumental works of this period. It must always be occasion for regret that the original drawings made by Abbot of the insects belonging to other orders which he depicted, the originals of which are preserved in the British Museum, were not published. Abbot was a careful observer and an accomplished draftsman, whose work deserved a better fate than to be simply buried in the portfolios where they still may be seen. To this period also belong the writings of Latreille,

and others of the enclycopedists, who collaborated with him, notably A. G. Olivier.

A work of great beauty for the times, which began to appear in 1806, is Hübner's *Exotische Schmetterlinge.* It continued to be issued until 1824, and was supplemented from 1818–1832 by Carl Geyer. In this quite a considerable number of North American lepidoptera are represented for the first time by recognizable figures. We also must not forget the writings of Palisot de Beauvois.

The earliest paper written by a native of America upon an entomological theme to which I have been able to find reference is an article by John Bartram, who was born in 1701 in Pennsylvania, and who in the Philosophical Transactions, published in London in 1745, gives "An Account of Some Very Curious Wasp-Nests of Clay in Pennsylvania," accompanied by a figure. He subsequently contributed several other brief entomological papers to the same journal. Moses Bartram, his son, in 1766 wrote an article entitled, "Observations on the Cicada or Locust of America, which Appears Periodically Once in 16 or 17 Years." This was published in 1767 in the *Annual Register*, the editor of which states that the paper had been "communicated by the ingenious Peter Collinson." The name of Collinson is perpetuated in the genus *Collinsonia*, one of the *Labiatæ*. Collinson aided Linnæus, the author of the genus, by sending him collections of exotic plants.

The real beginning of an indigenous literature dealing in a truly scientific manner with entomological subjects is found in the writings of Thomas Say, the Patron Saint of our Society, who was born in Philadelphia in 1787, the year in which the Northwest Territory was organized by the Congress of the Thirteen States, and in which the General Assembly of Pennsylvania granted the first charter for an institution of learning west of the Allegheny Mountains to the school, which is now the University of Pittsburgh. Thomas Say was one of the founders of the Academy of Natural Sciences in Philadelphia, which celebrated its centennial in 1912. The first paper from his pen, dealing with entomology, was entitled "Description of Several New Species of North American Insects." It appeared in the *Journal* of the Academy in June, 1817, being pages 19–23 of the First Volume of that important publication.

Only two years more than a century have elapsed since this first article upon entomology from the pen of Thomas Say was published. In this century there has occurred upon American soil an enormous extension of entomological research. The century must, however, be divided for our purposes into two epochs, one preceding the great Civil War, the other following it.

The epoch preceding the Civil War was far less fruitful than that which succeeded it. An examination shows that prior to 1865 the number of laborers in the field was small, and that among those engaged in studying North American insects European students and writers still outnumbered those upon the soil of the New World. The publications of native Americans, though valuable, were not numerous. The economic importance of entomology was not generally recognized. The impulse toward biological research, which arose after the announcement of the doctrines of Darwin, Wallace, and their fellow-laborers, had not yet been felt.

The principal repositories of entomological information in North America during the first half of the nineteenth century are periodicals which were issued by a limited number of learned societies. The Academy of Natural Sciences in Philadelphia led the way with its *Proceedings*. The American Philosophical Society, which had been founded earlier than the Academy of Natural Sciences, became the sponsor in its *Transactions* for a number of papers written by Thomas Say, the first being "A Monograph of the Genus Cicindela," which was followed by others. Both of these publications became favorite media for the followers of Say in which to announce their discoveries, and the results of their studies. In 1834 The Boston Society of Natural History was formed. Among its earliest publications were two papers, one upon "North American Coleoptera," the other upon the "Hymenoptera of America," written by Say, but which did not appear until some time after his death. In addition to these publications I may mention "The Annals of the New York Academy of Sciences," numbering thirteen volumes, beginning in 1819, and thereafter continued at irregular intervals; "The Annals of the Lyceum of Natural History of New York," the series extending from 1824 to 1877; the "American Journal of Science and Arts," often spoken of as "Silliman's Journal," the entomological content of which is relatively small, though important; "The Proceedings

of the California Academy of Natural Sciences," which began to appear in 1854. The first series of this latter journal consists of seven volumes, in which there are a number of valuable papers upon entomological subjects from the pens of Dr. Herman Behr, Henry Edwards, and others. It is a set of books now hard to get, as the greater part of the volumes were burned in a fire. In 1848 the Smithsonian Institution began to publish, and in the "Smithsonian Miscellaneous Collections," and the "Smithsonian Contributions to Knowledge" there were issued some important entomological papers.

Shortly after Say had begun in Philadelphia to give to the world the results of his researches, Thaddeus William Harris in the "New England Farmer" and the "Massachusetts Agricultural Repository" commenced to publish upon the Insects of Massachusetts, and continued until his death in 1856 to write instructively upon various insects injurious, or useful, and contributed a number of important papers of a descriptive and systematic nature to the literature. Harris was only second to Say as a pioneer in this field of inquiry, and his "List of the Insects of Massachusetts," published at Amherst by Professor Hitchcock in 1833, and his "Report on the Insects of Massachusetts Injurious to Vegetation" (which in an edition revised by Flint, is still a classic) greatly helped to develop an interest in economic entomology.

There were a few ardent and industrious students of entomology in the United States who labored during the half century preceding the Civil War besides those whom I have already mentioned. We owe gratitude to Melsheimer, Haldeman, Baron Osten Sacken, (the latter a member of the Russian Legation in Washington) and to Morris, as well as to Hagen, who was an importation from Europe, brought over by the elder Agassiz. Beside these there were a score or more of others, who were collecting, studying, classifying, preparing to give to the world the results of their labors, but belonging to a younger generation which was just about to appear upon the stage. They may be said to have been simply pluming their wings for flight at the end of the epoch of which I am speaking. They were triumphant in achievement at a later date, and a few, very few of them, survive to this day as the grizzled veterans of half a century ago.

I can still very vividly recall the later years of the epoch of which I have been speaking, and no doubt a few of my hearers this evening, whose memories take them back to their early days in school and college "before the war," can do as much. As a boy I had become interested in the study of insects. The only works upon the subject to which I had access at the time were an original copy of Say's "American Entomology," Jaeger's "Life of North American Insects," and Boisduval and Leconte's "Histoire Générale des Lepidoptères de l'Amérique Septentrionale." These books were supplemented through the kindness of an obliging congressman by the Annual Report of the Smithsonian Institution for 1858, containing instructions for the collection of insects, which I liked better than my catechism, and subsequently by a copy of Morris' "Catalogue." This was the sum of literature accessible to me. When I went to college at Amherst it was with a feeling of eagerness, founded upon a conviction that the doors of knowledge would at last be opened to me. I had collected a multitude of specimens, many hundreds of species in all orders. Imagine my despair when I asked my most genial instructor, Professor Edward Hitchcock, for assistance and guidance in determining my insects, to have that hearty and bluff worthy say to me: "Holland, there is not a man in Amherst who knows the first thing about insects." Professor C. B. Adams, the great naturalist, who, I had been told, had sometimes rocked me in my cradle in my West Indian home, where he lived during his stay in Jamaica, was dead and gone; his Jamaican insects in the Appleton Cabinet had mostly been devoured by *Dermestes;* I could do nothing, and therefore promptly gave up entomology and devoted myself to chemistry, geology, and botany, for teaching which there was more ample provision made. It was not until years later that I came back with vigor to the love of my boyhood. Blake, Cresson, Strecker, Scudder, Leconte, Horn, Grote, Henshaw, and many others were hard at work at that time, but I knew it not. I came to know them all in later years. But at that time there was no one to guide me. There was no army of entomological enthusiasts such as is found in our society with its membership of hundreds. The science had few votaries. They lived apart; their work had barely begun to see the light; and I knew them not.

We now come to the second epoch. On March 12, 1861, the Entomological Society of Philadelphia was constituted, being

the first entomological society formed in the New World. In 1867 its corporate name was changed to "The American Entomological Society." It published under its earlier name six volumes of *Proceedings*, and in 1867 began the publication of the "*Transactions of the American Entomological Society*," now numbering forty-five volumes. The activities of this important association led to emulation in other parts of the country. It was followed gradually by the organization of kindred societies in Cambridge, Brooklyn, New York City, Washington, and elsewhere. All of these associations began to publish sooner or later.

The economic importance of our science began to be more generally recognized. A very great influence was exerted in this connection by the labors of a young entomological enthusiast who had recently left his home in England and come to the city of St. Louis, where we are assembled this evening. At the early age of twenty-five years, in 1868, Charles Valentine Riley was made the State Entomologist of Missouri. He began the publication of his "Reports," continued until 1877. They are to this day most valuable. In 1878 he was put by the Government of the United States in charge of a Commission appointed to investigate the ravages of the Rocky Mountain Locust. Later he was transferred to the Bureau of Entomology in the Department of Agriculture in Washington. The successful administration of the Bureau from 1881–1894 was largely due to his initiative and to the fact that he had a genius for calling to his aid men of the greatest competence. His successor is our friend and fellow-member, Dr. L. O. Howard. *Serus redeat in cœlum!*

Among the men who were the cotemporaries of Riley, and even his predecessors, there should be mentioned Professor B. D. Walsh, and the late Dr. Asa Fitch, both of whom rendered distinguished services in the fields of pure and applied entomology. The labors of Walsh related to the insect-life of Illinois and the Mississippi Basin, Fitch dealt with the insects of the State of New York. The writings of both of these learned men are exceedingly valuable.

An impetus to the study of entomology in North America was not only given by the establishment of the Bureau of Entomology in Washington, but by the establishment of agricultural schools and colleges in the various states under the provisions of the "Morrill Land Grant Act," which was passed

on July 2, 1862, and was later thrice amended. An impulse was also received from the subsequent foundation of experiment stations, most of them in connection with the Land-grant Colleges. There also took place throughout the country a quickening of interest in so-called "Nature-studies," which has become intensified with the lapse of years. Entomology has found its way into the curricula of a number of the higher institutions of learning, and to some extent obtains a foothold in the schools of elementary grade in a number of the States. The ease with which material for study can be obtained in this branch of science, the wide range of biological facts which are brought into view, as well as the curious structure and beauty of many insects, appeal to many minds. While our science has not as yet assumed the same prominence which is accorded to botany in the curricula of institutions of learning, it nevertheless cannot any longer be regarded as an unpopular study.

I have alluded to the important influence exerted by the governmental recognition of the economic importance of entomology as having had its influence in the development of the science, and the multiplication of students in its various branches, but we ought not to fail to remember how large is the debt which is owing to the labors of individuals, who had little or no support in their labors from the governments of the States or from that of the Nation. Many of the foremost laborers in the field had to depend entirely, both in the prosecution of their researches and in the publication of the results, upon what their own pocket-books could provide, or upon the scant assistance which was given them by the learned societies to which they happened to belong. We are under profound obligations to the self-denying and patient labors of such men as Philip R. Uhler, Samuel H. Scudder, Alpheus S. Packard, William H. Edwards, Henry Edwards, John L. LeConte, and Dr. George Horn, to mention only a few of the illustrious dead, who brought to their work magnificent intellectual power, profound learning, great experience, and unquenchable enthusiasm. I have personal knowledge of the great sacrifices made by these men in their efforts to pave the way for those who should come after them. At great cost without hope of reward they laid the foundations upon which we are still building. None of the men of whom I am speaking, unless it be Packard and Scudder, received even indirectly assistance from the public

treasury. Two of Packard's great monographs were indirectly published at government expense; and Dr. Scudder's monumental work upon fossil insects and his indispensable "*Nomenclator Zoologicus*" were issued under governmental auspices. Otherwise these most prolific writers were compelled to depend upon their own resources or upon such help as could be derived from the learned societies, with which they were affiliated, or the serial journals, the pages of which were open to them. I recall in this connection the fact that the late William H. Edwards being desirous to publish the third volume of his "Butterflies of North America," a very expensive undertaking, wrote to me saying that in order to secure the necessary funds he had determined to offer his entire collection to the Trustees of the British Museum, hoping that they might purchase it, as they had already purchased the collection of A. R. Grote, containing his types of the moths of North America. I forthwith wrote to him, proposing that I would assume the expense of publishing the third volume of his work, provided that the collection should be ultimately turned over to me. The offer was promptly accepted. I only mention the incident, because it throws light upon the difficulties under which some of the most important works at our command were brought into being by their authors. Dr. Scudder told me that his "Butterflies of New England" had involved a personal outlay on his part of nearly ten thousand dollars, and that he would deem himself fortunate if the sales ultimately should return to him the capital he had invested, not speaking of the time and labor he had expended. Many of the most important works we possess are due to individual initiative in their conception and execution. A very remarkable work of this sort, which it might have been the glory of a nation to produce, is the *Biologia Centrali-Americana*, which stands as a monument to the learning and the generosity of a wealthy Englishman, my friend, the late F. Ducane Godman. Parts of this colossal work were written by Americans, notably the Section dealing with the Diptera, which was produced by our lamented colleague, Professor S. W. Williston.

Proceeding to a somewhat closer review of entomological activity in North America during the past fifty years, it is seen that the number of periodicals accessible to entomologists, who may desire to publish their observations, has been greatly

increased. In the year 1860 there were only five or six such journals; today there are about fifty. Of course not all of these are of equal importance and dignity. The day, however, is past when a student of entomology in North America need fear that his work, if of value and significance, need long languish in darkness, and fail to be made known to his fellow-laborers.

Another fact worthy of note is not merely the multiplication of learned societies to which I have already alluded, but of institutions for research and for the promotion of a knowledge of the natural sciences. In 1860 there were only half a dozen museums in the new world, and these were quite in their infancy. Today there are a multitude of museums, some of them well-housed, well-equipped, and well-supported, which are fit to become the ultimate repositories of important entomological collections, and there are a number of endowed institutions, which in a broad manner promote intensive studies in natural science.

In 1860 the number of men and women engaged in entomological pursuits in the United States and Canada were numbered by scores; today they are numbered by thousands.

In 1860 there was not a single manual dealing with the science issued from an American press. Packard's "Guide to the Study of Insects" was the first to appear, and it came out in 1869. Today there are a number of textbooks easily available, and the young man or woman who wishes to make a serious study of the subject is not forced to fall back, as we, their elders, were, upon the pages of European writers, such as Burmeister.

The literature needed by the specialist in 1860 was scanty. Today it has grown to be so enormous that complaint is being made. Our greatest need at the present time is condensation. Compact manuals covering the various branches of the science are called for. Hand-books, such as the botanists have provided, covering the various orders, should be prepared.

In speaking of the growth of the literature of our science in America, I have been interested in examining the lists of entomological publications furnished by the "Zoological Record." In the year 1864, when that journal first appeared, one hundred and forty-nine papers upon entomology are listed, only five of which are from the pens of North American writers. I am quite sure that the figures given for that year are incorrect.

The learned editors did not have access to, or accidentally overlooked a number of papers, which in that twelvemonth were published by American students. But they also overlooked the writings of a number of authors in other lands. For purposes of statistical comparison we may accordingly accept their figures as approximately correct. It appears in consequence that only 3.3 per cent of the entomological literature of the year 1864 was American in its origin. The "Zoological Record" for 1913 lists 2967 papers upon entomology, which had fallen under the eyes of the compilers. Of these 627, or more than 21 per cent, were written by Americans or Canadians. In 1916, owing to the war, the number of contributions to scientific literature fell off very greatly. Only 1821 papers upon entomological themes are listed by the "Zoological Record" for that year, 1146 less than in 1913. Of this total 557 were published by citizens of the United States and Canada, more than 30 per cent of the total number of titles. In view of the fact that the "Zoological Record" seldom takes account of any but papers having taxonomic import, and that the vast body of papers dealing with economic questions in the field of entomology are not recorded, save exceptionally, these figures have great significance as showing the wonderful increase which has taken place in entomological activities in North America during recent years. The output of literature in our science has been multiplied ten-fold among us in the past five decades.

Another evidence of progress is discovered when we examine into the lists of species known to occur in North America, comparing them with earlier lists, so far as such exist. Taking up the "Catalogue of the Described Lepidoptera of North America," prepared by the Rev. John G. Morris and issued by the Smithsonian Institution in May, 1860, we find that he enumerates for the whole continent from Labrador to Panama, only 328 diurnal lepidoptera, or butterflies, of which 225 belong to the region called Boreal America by some, or by others the Nearctic Region. The latest check-list, published by Barnes & McDonough, enumerates 661 species of butterflies as occurring in Boreal America. There have thus been added to the faunal list 436 species, the number given by Morris having been approximately trebled in the past five decades. There is even a greater advance shown in the case of the *Heterocera*, or moths.

Morris gives the number of species of moths credited to the North American continent, of which he had knowledge, as 1340, a large number of which belonged to the Neotropical Area. Barnes & McDonough, restricting themselves to Boreal America, list 7834 species as belonging to our fauna. The number of species of *Heterocera* known to occur in Boreal America has therefore since 1860 increased at least seven-fold.

What I have stated as to the Lepidoptera is typical of what has taken place in the other orders. The earliest list of beetles was prepared by Melsheimer, who confined himself to those species, which he knew to occur in Pennsylvania. He catalogued 1363 species. Crotch's Check-List, published in 1873, enumerated 7450 species of beetles found north of the Rio Grande of Texas. The supplement to his List by Austin raised the number to 9704 in the year 1880. The Revised List by Henshaw, with the Supplements, brought the total to 11,256 in the year 1895. The Catalogue by C. W. Leng, which will appear shortly, is reported to bring the number of species known in this faunal area up to 18,547 species, exclusive of sub-species and varieties.

The writings upon the Diptera by Osten Sacken and others, which appeared about 1860, yield upon examination a total of known species in this order of less than 1,000. The great Catalogue prepared by our distinguished colleague, Dr. J. M. Aldrich, issued in 1905, gives a total of species found on the continent from the highest north to Panama of 9350. Some of these species may not be valid, but most of them are, and the field has only been partially explored.

In all the other orders a similar increase in the number of known species has taken place, and where at the beginning of the epoch only a few hundreds of species at the most were listed, we now discover that there are thousands known.

To have prepared an approximately correct estimate of all the recorded species in all the orders ascertained to be found upon the soil of the United States and Canada is a labor for which I have not had the necessary time. It would have required the careful examination of hundreds of papers, and extensive use of my adding-machine. I venture the statement, however, that there are probably not far from 60,000 species known, or in process of being named and described. Not more than one-sixth of these were known to science fifty years ago.

There has been prodigious activity along taxonomic lines displayed by students of the subject during the past five decades.

One of the most marked developments of the past half-century has been the growth of interest in the economic aspects of entomology. I have alluded already to the work done by Harris, Walsh, Fitch, and Riley. These men have had an army of enthusiastic successors, among them some who have rivalled and even surpassed the most excellent labors of those I have just named. Most of them are still with us, including our Nestor, Dr. Stephen A. Forbes. An English entomologist of renown, speaking to me some time ago of certain entomological reports which he had received from the United States Department of Agriculture and from various Agricultural Experiment Stations, said: "We have nothing like this in the Old World. The United States and the several States are greatly in advance of the European nations in your application of science to the arts of the agriculturist. I marvel at what you are doing."

But it is not only in connection with agriculture that the entomologist has proved his worth, but also in the field of medicine, as you are well aware. The study of disease-bearing insects, and the ascertainment of methods of prophylaxis are fields in which American students of our science have achieved results, which must prove of inestimable service to coming generations. May I say a word in this connection concerning the splendid "Monograph of the Culicidæ" in four great quarto volumes, prepared by our colleague, Dr. L. O. Howard, and his associate, Messrs. H. G. Dyar, and F. Knab which has just been published by the Carnegie Institution of Washington. I have carefully examined it, and am sure that it is the best piece of work in our science which the Carnegie Institution has thus far been allowed the privilege of publishing. For years to come it will be the standard work of reference for students in this difficult field of investigation.

Another sphere in which there has been marvelous progress not only in our country, but throughout the world, is that of technique. I might spend hours in speaking of this, but must content myself with a few words only. There has been a wonderful advance and improvement in the instruments and methods of research. Take that familiar tool, the microscope, which we all must constantly use, how wonderfully has it been improved! We have in the Carnegie Museum a microscope

which in 1736 was presented by Linnæus to his fellow-student and friend, Bernard Jussieu, when they were students in Paris. It is for that day a good instrument, and I can still see through it, but there is a gulf between it and the instruments we employ today as wide as that between a toy pop-gun and the French 75s, which roared forth victory on the European battle-front. Take such a simple commodity as insect-pins as an example of what the use of modern machinery can accomplish. Pins in the days of Linnæus were made by hand; they were costly; they were clumsy. For mounting the minuter forms the best Linnæus had were about as good as marlin-spikes. Take the thousand and one odds and ends of apparatus which we employ in our work, how marvelously have all these things been improved! Photography has come to our aid, and with its help we are able to get and keep records, which the fathers would not have dreamed to be possible. As I sat and listened yesterday and today to the fine papers which were being read, and which were being illustrated by magnificent projections with the help of the electric lantern, I could not help in thought contrasting the present with the past, and wondering whether you younger men appreciate the inheritance into which you, through the labors of others, have come.

The review I have made is necessarily brief. I cannot avoid thinking that it should awaken in us satisfaction. The great field which is ours has at least been partially conquered. There remains, however, a vast amount of work to be done; it is far from being exhausted. Of only comparatively few species are the life-histories thoroughly known; the phylogenetic relationships of various groups and species await investigation; no doubt there are thousands of species yet to be discovered and named; and, in spite of the fine work done by Scudder and by Cockerell in paleontology, there must be innumerable species of fossil insects to be found and described. Many questions in economic entomology still await solution. There is reason, therefore, for you younger men to regard the future with hope and pleasurable anticipation. I am sure from what I have seen during the sessions here that we have before us a future still more brilliant than the past has been.

In conclusion, in these times of strife and discord it is a pleasure to recall how fraternal have been the relationships which have been maintained by all workers in our special field

of inquiry. I desire especially to emphasize the cordial relationships which have been maintained during all these years between students living south of the St. Lawrence with those living north of that river. One of the best of all the entomological journals on the Continent is the "Canadian Entomologist." As it is one of the oldest, so it is one of the best-sustained publications of its kind. "The Entomological Society of Ontario" is a splendid organization, in which most of the leading workers within the United States have felt it an honor to have membership. For all practical purposes the entomologists of British North America and of the United States form one united brotherhood. Behold how good and pleasant it is for us thus to dwell together in unity! May I not express the hope that the friendly relationship which has so long been maintained among us may remain indissoluble, and the same spirit which has prevailed between these two great bodies of workers in the New World may extend to all brotherhoods of other nations, and that through our scientific friendships we all may help to bring in the reign of universal peace, the thought of which is dominant among us, and is emphasized by the anniversary of the birth of THE PRINCE OF PEACE, which we have just celebrated.

THE MUSCULAR SYSTEM OF GRYLLUS ASSIMILIS FABR. (=PENNSYLVANICUS BURM.)

E. Melville DuPorte,
MacDonald College (McGill University), Canada.

Introduction.

This paper gives an account of the musculature of *Gryllus assimilis* Fabr., one of our common field crickets. It includes also a brief description of the internal skeletal structures inasmuch as a knowledge of these is necessary to understand the method of attachment of the muscles.

In his comprehensive study of the thorax of *G. domesticus* Voss ('05) describes the musculature of the veracervix, the thorax and the anterior segments of the abdomen. Berlese ('09) figures some of the thoracic muscles of *G. campestris*. The musculature of these two insects agrees very closely with that of the allied *G. assimilis*.

In naming the head muscles, including those of the neck, I have employed terms descriptive of their functions without reference to possible segmental homology. I have followed Voss and Berlese's system in naming the thoracic and abdominal muscles, and have not described these muscles in detail, owing to their general similarity to the muscles of *G. domesticus* as described by Voss ('05). The numbers used by Voss are inclosed in square brackets after the description of the muscles; the names which he used for the cervical muscles are also thus inclosed, Crampton's term *veracervix* being substituted for *microthorax*.

I have thought it best to avoid the use of Latin terms. The numbers used have no significance apart from their reference to the figures.

I. THE ENDOSKELTON.

(Figs. 1, 2 and 3).

THE HEAD (Fig. 2). The well developed tentorium consists of a central plate (T.C.) from which two pairs of processes are given off. The base of the central plate forms the ventral edge of the occipital foramen (F.O.) The central plate lies in a horizontal plane approximately parallel to that passing through the median lines of the pleura. A constriction near the base gives this plate a more or less urn-shaped outline. At each of its apical angles it bears a large triangular anterior plate (T. A.), the base of which is attached to the lower edge of the gena near the base of the mandible. Immediately behind these processes second and smaller pair arises from the central plate. These are the posterior processes (T. P.); they are columnar in form and run obliquely forward and upward, fusing with the epicranium near the base of the antennae. Between the two anterior processes, the central plate and the epicranium, three foramina are formed, an anterior one (F. A), through which the œsophagus passes from within the epicranium to the mouth, and two lateral foramina (F. L.) through which the crura cerebri and the adductor muscles of the mandibles pass.

Three tuberculate apodemes arise from the epicranium at the edge of the occipital foramen, a median dorsal process (A. M.) and two lateral processes (A. L.) These processes serve for the insertion of certain of the muscles which move the head.

THE VERACERVIX OR NECK. (Fig. 1, Cerv.) There are five paired and one unpaired sclerites which support the cervical membrane and on their inner surfaces serve as points of attachment for some of the neck muscles. These are the three intersternites (Fig. 1, i.st. γ, δ, ϵ) or ventral cervical sclerites, the second of which is median and unpaired; the large interpleurite (Fig. 1, i.p.) bearing an inward projecting process (ap. ip.) at its anterior end, and the two intertergites (Fig. 1, i.t. α & β) or dorsal sclerites. The form and arrangement of these sclerites may be readily seen by referring to Fig. 1. As will be shown later the interpleurite is the only one of much importance for the attachment of muscles.

THE PROTHORAX (Fig. 1, T_1). A lateral entosternite or furca (es) arises from each of the posterior ends of the inverted V-shaped furcasternite (Fs) and extends across the opening of the fore-leg. The flattened distal portion is closely appressed to the inner face of the epimeron and entopleurite. The small spina or median entosternite (es. m) is a flattened three-lobed plate arising from the posterior edge of the spinasternite (Ss). The greater portion of the pleuron is overgrown by the pronotum and lies on the inner side of this sclerite (see DuPorte, '19). The contiguous edges of the episternum (Ep) and epimeron (Em) are infolded to form a deep entopleurite (ep) which projects ventrally to form a ball and socket articulation with the outer angle of the coxa.

THE MESOTHORAX (Fig. 1, T_2). The median entosternite (esm) or spina is a three-lobed disk attached by a short stalk which projects inwards from the furcasternite between the bases of the lateral entosternite (es). The proximal section of the lateral entosternites is more or less cylindrical, while the distal section is expanded and folded to form a pocket into which fits a process from the entopleurite. The entopleurite (ep) is formed from the inflexed contiguous edges of the episternum and epimeron. Its dorsal extremity projects beyond the edges of the episternum and epimeron, forming the pleural wing process. At its ventral end it gives off a spur-shaped pleural process which fits into the pocket of the entosternite. The two are connected by a pair of short muscles, one originating from either side of the spur and inserted on the inner sides of the pocket. Thus a strong arch is formed above the leg opening. From this arch certain of the leg muscles originate.

A pair of intersegmental sclerites (in), probably the pretergite, lies transversely in the sutural membrane between the pronotum and mesonotum, the inner ends are attached to the anterior edge of the mesoscutum and the outer ends extend to the anterior edge of the base of the wing near the anterior piece of the first axillary. There is a large basalar sclerite (b.s.) and a small subalar plate (s.a.p.)

THE METATHORAX (Fig. 1, T_3). The endosclerites in this segment are similar to those of the mesothorax, except that there is no median entosternite. The intersegmental sclerite (in_2) comes in close contact with the posterior process at the lateral end of the meso-postscutellum. There are one large and

one small basalar sclerites (b.s.) and two subalar plates (s.a.p.), the anterior one elongated, the posterior smaller and broadly oval.

THE ABDOMEN (Figs. 1 and 3). Several small chitinous plates are imbedded in the pleural membrane of the abdomen. The parasternal plate (Fig. 1, ps.p.) situated immediately behind the base of the third coxa, is the largest of these sclerites. Judging by its musculature this plate is apparently a detached portion of the first and second abdominal sternites. In each segment from the third to the seventh there are three small linear pleural sclerites, one ($p.s_1$) near the anterior end, one ($p.s_2$) near the posterior end and the third ($p.s_3$) in the middle of the segment nearer the tergum than the two other pleural sclerites. In the third segment the third pleural sclerite is large and receives muscles from the second and third sternites.

From the anterior edges of the eighth and ninth tergites in the female, a flattened blade-like process (Fig. 3, PA_8, PA_9) projects forward. These processes serve as points of origin for certain of the muscles which move the ovipositor. The supra-genital plate bears a median knife-like process (Fig. 3, P.S.G.) which serves the same purpose.

A ventral (Fig. 3, v_1, v_2) and a dorsal process (d_1, d_2) are given off from the base of each gonapophysis; these serve as points of insertion for muscles of the ovipositor. On each side the two dorsal processes (d_1 and d_2) are closely interlocked. The ventral processes (v_1) of the dorsal pair of gonapophyses (G. D.) are connected by means of a transverse chitinous rod (Fig. 3, t.c.) which bears a flat, thin unpaired process (m) in the middle of its anterior face.

II. THE MUSCLES OF THE HEAD.

The muscles of the head may be divided into (a) the muscles of the mouthparts, (b) the muscles of the antennae, (c) the muscles of the pharynx and oesophagus, and (d) the cervical muscles, or those which control the movements of the head as a whole.

(*a*). *The Muscles of the Mouthparts.*

THE LABRUM.—The *Abductors of the Labrum* (Figs. 7 and 9, abd.lbr.) are a pair of contiguous muscles, straight with parallel

fibres, originating in the middle of the front immediately beneath the median ocellus and inserted by a short tendon into the base of the labrum, one on each side of the median line.

The *Adductors of the Labrum* (Figs. 7 and 8, ad. lbr.) Two three-headed muscles inserted by means of a small tendon, one in each of the basal angles of the labrum. The outermost head is attached to the front near the inner side of the antenna, the innermost near the median line adjacent to the origin of the abductor, and the middle head midway between these two. In some specimens only the outer and inner heads were present.

The Mandibles are articulated with the epicranium by means of a ginglymus joint permitting motion in one plane only, consequently there are but two muscles, an adductor, and an abductor. The *Adductor of the Mandible* (Figs. 4, 5 and 6, ad. md.) is a pyramidal complex muscle and, owing to the fact that in the cricket the mandibles are strong crushing jaws, is the largest and strongest muscle in the head. Its base occupies the whole top of the head as far forward as the eyes and upper edge of the brain. It is inserted into the inner angle of the base of the mandible by means of a large tendon composed of three flat transparent laminæ (Fig. 4, t).

The Abductor of the Mandible (Fig. 4, abd. md.) is smaller and has its origin in the epicranium beneath and behind the eye. It is inserted into the outer angle of the mandible by means of a long flat tendon.

The Maxillae. Owing to the segmented structure of the maxilla, its muscles are more numerous and complicated than those of the labrum and mandible. The *Abductor of the Maxilla* (Figs. 12 and 14, abd. mx.) is a thick triangular muscle originating in the gena and postgena near the origin of the abductor of the mandible. It is inserted by means of a long narrow three-faced tendon into the inner angle of the second segment of the cardo. The hinge on which the maxilla turns lies mesad of the insertion of the tendon along the upper edge of the proximal segment of the cardo (i. e., the edge near the letter C_1 in Fig. 14). The opening of the maxillae therefore causes a pushing upwards of the outer portions of their bases (the outer edge of C_2). Conversely the upward pull given to this portion of the maxillae by the contraction of the abductors causes them to open.

There are two *Adductors of the Maxilla* which both take their origin in the lower surface of the central plate of the

tentorium. The *First Adductor* (Figs. 13 and 14, ad. mx.) is inserted into the first segment of the cardo at its junction with the second segment near the insertion of the abductor. The *Second Adductor* (Figs. 12 and 14, $ad._2$ mx.) is also inserted into the cardo but at the outer angle of the second segment near the suture between the cardo and the stipes.

The *Flexor of the Maxilla* (Figs. 13, 14 and 16, fl.mx.) is a strong compound muscle which also originates from the lower face of the central tentorial plate. It is inserted into a flat elongated apodemal surface (Fig. 15, ap.st.) along the inner edge of the outer wall of the stipes. This muscle and the two adductors working together are capable of exerting considerable force in the closing of the maxillae.

The *Flexor of the Lacinia* (Fig. 14, fl.lac.) lies wholly within the stipes. It originates by a broad head near the outer angle of the base of the stipes, runs diagonally across the stipes and is inserted by a short flat tendon into the inner angle of the base of the lacinia.

The *Flexor of the Galea* (Fig. 15, fl.g.) is a smaller muscle having its origin in the outer integument of the stipes opposite the palpus and its insertion in the inner angle of the base of the galea.

Within the stipes there are two muscles which move the palpus. They both originate in the outer integument near the apodeme into which the flexor of the stipes is inserted. The proximal muscle is the *Extensor of the Palpus* (Fig. 15, ext.p.) and is inserted in the lateral edge of the base of the palpus. The second muscle, inserted at the opposite side of the base of the palpus is the *Flexor of the Palpus* (Fig. 15, fl.p.). Within each of the first three segments of the palpus there are an extensor and a flexor of the palpal segment. The *extensor* (Fig. 15, ext.p.s.) arises at the outer side of the base of the segment and the *flexor* (fl.p.s.) at the inner side. They are inserted respectively into the outer and inner sides of the base of the next distal segment.

THE LABIUM. The *Retractor of the Labium* (Figs. 16 and 17, r.lb.) is a long flat muscle with its plane at right angles to that of the labium. It originates in the base of the central plate of the tentorium near the inner angle of the postgena, and is inserted into the side of the ligula near the base of the paraglossa.

The *Abductor of the Labium* (Figs. 16 and 17, abd.lb.) is a straight parallel-fibered muscle. It originates from a small tubercle on the basal edge of the tentorium and is inserted at the outer angle of the distal edge of the mentum.

The *Adductor of the Labium* (Figs. 16 and 17, ad.lb.). The two adductors are contiguous at their origin near the middle of the base of the submentum, but diverge in their course. They are inserted by means of small semicircular tendons into the base of the ligula not far from the middle line.

The *Adductor of the Paraglossa* (Fig. 17, ad.pgl.) originates from the base of the ligula near the median line, and runs diagonally to the base of the distal segment of the paraglossa.

The *Adductor of the Glossa* (Fig. 17, ad.gl.) originates in the ligula and is inserted into the lateral side of the base of the glossa.

The musculature of the labial palpi is similar to that of the maxillary palpi, but the flexor and extensor arise from a narrow elongate, median apodeme (Figs. 6 and 17, ap.lb.) which is given off at the point where the labium and hypopharynx unite, and projects backward as far as the mentum.

The Hypopharynx. The *Depressors of the Hypopharynx* (Fig. 6, dep.hyp.) are two muscles which originate from the lower side of the central plate of the tentorium and are inserted into the upper integument of the base of the hypopharynx near the point at which the pharynx narrows into the oesophagus. The depression of the hypopharynx at this point assists in enlarging the oesophageal canal.

The *Elevator of the Hypopharynx* (Fig. 6, el.hyp.) originates in the face in front of the median ocellus, and is inserted on the outer surface of the hypopharynx near the entrance to the oesophagus. This muscle pulls the base of the hypopharynx up against the roof of the pharynx, closing the entrance to the oesophagus.

The *Compressor of the Hypopharynx* (Fig. 6, c.hyp.) originates with its fellow of the opposite side from the median line of the lower side of the hypopharynx at its junction with the labium. The two muscles diverge, running obliquely backwards and upwards, and are inserted into the outer angles of the upper side of the base of the hypopharynx in front of the oesophagus. By compressing the hypopharynx these muscles enlarge the pharyngeal opening.

The *Retractor of the Hypopharynx* (Fig. 6, r.hyp.) is a long flat muscle having its head contiguous to that of the retractor of the labium. It runs parallel to this muscle and is inserted into the side of the hypopharynx near the junction between this organ and the labium.

THE EPIPHARYNX. There is a single median epipharyngeal muscle (Fig. 9, eph.m.) which has the form of a truncated cone. Its points of attachment are the inner sides of the labium and epipharynx.

(*b*). *Muscles of the Antennæ.*

There are three muscles within the head which bring about the movements of the antenna as a whole. (Fig. 5, m.ant.)

The *Extensor of the Antenna* (Fig. 11, ext.ant.) originates from the dorsal side of the lateral angle of the anterior tentorial plate and is inserted into the lateral side of the base of the first antennal joint.

The *Flexor of the Antenna* (Fig. 11, fl.ant.) This muscle has its origin near the apical angle of the central tentorial plate in the angle formed by the anterior and posterior plates. It is inserted at the inner side of the basal margin of the first antennal segment.

The *Depressor of the Antenna* (Fig. 11, dep.ant.) has a very broad head attached to the dorsal side of the anterior arm of the tentorium and extending from the epicranium to the attachment of the anterior plate to the central plate. It tapers rapidly and is inserted into the ventral side of the basal segment of the antenna.

Within each antennal segment there is a *flexor* (Fig. 10, fl.a.s.) and an *extensor* (ext.a.s.) similar to those described in the palpi.

(*c*). *Muscles of the Pharynx and Oesophagus.*

The circular or constrictor muscles are well developed in the oesophagus. In addition to these there are several muscles originating in the wall of the head or the tentorium which function as dilators and suspensors of the pharynx and oesophagus.

The *Precerebral Dorsal Dilators* (Figs. 5 and 6, pr.d.) There are usually three paired dilator muscles lying in front of the brain. The *first* ($pr.d._1$) has its origin in the clypeus and is

inserted into the roof of the pharynx at a short distance from the median line. The *second* (pr.d.$_2$) originates in the front above the clypeus and is inserted into the pharynx behind the first. The *third dilator* (pr.d.$_3$) is inserted into the roof of the oesophagus just in front of the brain. Its origin is in the epicranium in front and to one side of the median ocellus. A fourth muscle is sometimes present.

The *Post-cerebral Dorsal Dilator* (Fig. 6, pst.d.) originates in the epicranium immediately in front of the adductor of the mandible and is inserted into the oesophagus just behind the brain and a short distance from the dorsal median line.

The *Lateral Dilator* (Fig. 5, l,d.) arises in the epicranium at the inner side of the compound eye and is inserted into the lateral median line of the oesophagus beneath the brain.

The *Ventral Dilators* (Fig. 6, v.d.) are two rows of small muscles which originate from the upper surface of the central plate of the tentorium and are inserted into the lower wall of the oesophagus a short distance on each side of the median line.

(*d*). *Cervical Muscles.*

(Figs. 18 and 19.)

The muscles which control the movements of the head may be classified as depressors, elevators, retractors and rotators of the head.

LONGITUDINAL MUSCLES.

(a) **Sternal.**

1. *The Inner Depressors of the Head* originate from the enlarged basal portions of the pro-entosternites and are inserted into the middle of the hind edge of the central tentorial plate. [137, 5th sternal muscle of the veracervix].

2. *The Outer Depressors of the Head* originate immediately laterad of the preceding, and are inserted into the dorsal surface of the central tentorial plate. [136, 4th sternal muscle of the veracervix].

3. *The Short Depressor of the Head*, origin, pro-entosternite, insertion, into the cervical membrane just beneath the ventral angle of the interpleurite. [135, 3rd sternal muscle of the veracervix].

(b) Dorsal.

4. *The Elevator of the Head.* A strong double intersegmental muscle. One head originates from the first intersegmental sclerite (Fig. 1, in.), the other from the posterior edge of the pronotum near the median line. The two are inserted by a common elongated tendon into the lateral apodeme (Fig. 2, AL.) of the dorsal border of the occipital foramen. [139, 140, 1st and 2nd tergal muscles of the veracervix].

(c) Pleural.

5. *The Retractor of the Head.* Origin, anterior edge of the pro-episternum; insertion, lateral side base of head. [138, Fifth (a) sternal muscle of the veracervix].

PLEURAL MUSCLES.

(a) Noto-pleural.

6. *The First Rotator of the Head.* Origin, anterior edge of the pro-episternum; insertion (1) median apodeme (Fig. 1, A. M.) of the dorsal border of the occipital foramen, and (2) anterior edge of the first intertergite. [141, 142, first and second external rotators of the head].

7. *The Second Rotator of the Head* originates from the anterior edge of the pronotum near the median line and is inserted into the postero-dorsal edge of the interpleurite near the dorsal angle. [143, the intersegmental muscle of the veracervix].

8. *The Third Rotator of the Head,* originates from the pronotum just in front of the distal end of the pleuron and is inserted into the ventral edge of the interpleurite. [144, second intersegmental muscle of the veracervix].

9, 10. *The Fourth and Fifth Rotators of the Head.* Both originate from the interpleurite and are inserted into the median apodeme (Fig. 1, A. M.) of the dorsal border of the occipital foramen. [146, 147, second and third dorsoventral muscles of the veracervix].

11. *The Sixth Rotator of the Head.* From the apodeme of the interpleurite to the lateral apodeme of the foraminal border. [148, fourth dorsoventral muscle of the veracervix].

12. *The Seventh Rotator of the Head.* Origin, apodeme of interpleurite; insertion, neck membrane behind the first intertergite. [145, first dorsoventral muscle of the veracervix].

(b) Sterno-pleural.

13. *The Cruciate Rotators of the Head*, originate from the anterior edge of the procoxae and are inserted into the narrow anterior portion of the interpleurite of the opposite sides. [134, the second sternal muscle of the veracervix].

Voss, ('05), regarding the cervical interpleurite as a sternal sclerite, describes 13 as a longitudinal sternal muscle, and 6 to 12 as dorsoventral muscles. I have followed Crampton ('17) in regarding the interpleurite as a pleural sclerite, in which case these muscles are sterno-pleural and noto-pleural respectively.

The several rotators working in pairs function as elevators and depressors.

III. MUSCLES OF THE THORAX.

A. The Prothorax.

LONGITUDINAL MUSCLES.

(a) Sternal.

XIII. *The First Prosternal Muscle* (Fig. 21) is a flat unpaired median muscle which originates in the posterior edge of the median entosternite spira of the prothorax, and is inserted into the anterior edge of the spira of the mesothorax. A retractor of the thorax. [102].

14, 14a. *The Second Prosternal* (Figs. 20 and 21). From the median entosternite, into the anterior side of the base of the coxa. A weak extensor of the coxa. [103].

15. *The Third Prosternal* (Fig. 20). From the prothoracic spira obliquely backwards into the distal section of the mesofurca. [104].

16. *The Fourth Prosternal* (Fig. 20). Origin, base of prothoracic furca; insertion, mesothoracic furca near 15. [105].

17. *The Sixth Prosternal* (Fig. 20). Origin, furca near 16; insertion, mesothoracic spira. [107].

18. *The Seventh Prosternal* (Fig. 20). From the spira into the base of the furca. [108].

The Longitudinal Prosternal muscles are retractors pulling the prosternite and mesosternite together and bending the head and prothorax downwards. The Longitudinal Pronotals are the antagonist muscles of the prosternals.

(b) Dorsal.

XIX. *The First Pronotal Muscle* (Fig. 20). From the posterior edge of the pronotum near the median line, into the inflexed posterior border of the neck membrane. [109].

19, 20. *The Third Pronotals* (Figs. 20, 21). From the first intersegmental sclerite into the median ridge of the pronotum. [111, 110].

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

21. *The Prothoracic Intersegmental Muscle.* From the base of the furca into the outer angle of the first intersegmental sclerite. Rotator of the thorax. [112].

(b) Noto-subcoxal.

22. *The First Dorsoventral Muscle of the Prothorax* (Fig. 20). From the pronotum immediately behind the distal end of the epimeron into the trochantin by a long flat tendon. A strong conical muscle. An extensor of the coxa.* [113].

(c) Noto-coxal.

23, 23a. *The Second Dorsoventral* (Fig. 20). Origin, in the pronotum immediately above the distal end of the pleuron usually with two (sometimes three) adjacent heads; insertion into the posterior edge of the coxa by a long thin tendon. A flexor of the coxa. [114].

24, 24a. *The Sixth Lateral* (Fig. 21). From the posterior side of the pronotum into the latero-caudal edge of the coxa by a broad tendon. Two heads—24 is a stout-bellied muscle while 24a is quite slender. Flexor of the coxa. [121].

(d) Noto-trochanteric.

25, 25a–25e are the six heads of a complex muscle inserted by a common tendon into the inner angle of the base of the trochanter. Together they form the extensor of the femur. The origins of the various heads are noted in their proper places below.

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* When the coxa is pulled backwards it moves upwards towards the sternum. A forward pull moves it also downwards away from the body. I have designated the muscles which bring about these motions as *flexors* and *extensors* respectively, reserving the terms *adductor* and *abductor* for those muscles which pull the coxae inwards towards each other and outwards away from each other.

25b. *The Sixth (a) Lateral* (Fig. 21) originates from the lateral anterior edge of the pronotum. This muscle takes a sharp bend, passing between the pronotum and the pleuron, and enters the coxal cavity on the posterior side of the entosternite. [122].

25d. *The Eighth Dorsoventral* (Figs. 20, 21) originates in the dorso-lateral portion of the pronotum just behind the posterior edge of the epimeron. [117].

PLEURAL MUSCLES.

(a) **Pleuro-pedal.**

25. *The Fourth Lateral* (Fig. 20). Origin, the distal anterior edge of the inner face of the episternum. [119].

25a. *The Fifth Dorsoventral* (Figs. 20, 21) originates from the inner face of the epimeron. [115].

25c. This is a short muscle originating in the epimeron, near the ventral end, quite close to the leg. At its point of attachment it is pressed closely between the epimeron and the distal blade of the entosternite.

25e. This also is a very short muscle originating in the outer face of the entopleurite opposite the origin of 25c. (Not figured).

26. *The Fourth Lateral* (Fig. 21). Origin, from the episternum, by a curved head bending round the distal end of the entopleurite; insertion, by tendon into the latero-anterior edge of the coxa. Extensor of the coxa. [118].

27. *The Fifth Lateral* (Fig. 21). From the inner face of the episternum near its attachment to the ventral edge of the pronotum, into the lateral angle of the trochantin. [?120].

(b) **Noto-pleural.**

XXVIII. *The Dorsoventral Muscle* (not figured), is a very short, but strong muscle binding the pleuron closely to the pronotum.

(c) **Sterno-pleural.**

XXIX. *The Furca-entopleural Muscle* (not figured), also very short, binds the distal portion of the furca to the entopleurite. [132].

STERNAL MUSCLES.

(a) Sterno-pedal.

28. *The First Pedal Muscle of the Prothorax* (Fig. 21). From the base of the furca into the anterior border of the coxa. Extensor of coxa. [127].

29. *The Second Pedal Muscle* (Fig. 20). From the furca near its base into the posterior border of the coxa. Flexor of the coxa. [128].

30. *The Third Pedal Muscle* (Fig. 21). From the furca above the leg cavity into the meso-caudal edge of the coxa. An adductor and flexor of the coxa. [129].

31. *The Seventh Pedal Muscle* (Fig. 21). From the spira into the posterior border of the coxa. Probably a weak flexor or rotator, but of little functional importance. [131].

B. The Mesothorax.

LONGITUDINAL MUSCLES.

(a) Sternal.

32. *The Second Mesosternal Muscle* (Fig. 21). Homologue of 14. [66].

33. *The Third Mesosternal* (Fig. 20). Homologue of 15. [67].

34. *The Fourth Prosternal* (Fig. 20). Homologue of 16. [68].

(b) Dorsal.

35. *The First Mesonotal Muscle* (Fig. 21). A broad flat muscle near the dorsal median line originating from the entotergite of the metathorax and inserted into the anterior border of the mesoscutum. This and the next are retractors of the thorax drawing the meso- and meta-tergites together. [69].

36. *The Second Mesonotal* (Fig. 20). Similar to 35 in origin, but inserted into the first intersegmental sclerite. Lies on the inner (ventral) side of 35. [70].

XXXVI. *The Third Mesonotal* (Fig. 21). An oblique muscle running from the second intersegmental sclerite to the mesoscutellum. [71].

DORSOVENTRAL MUSCLES.

(a) **Tergo-sternal.**

37. *The Mesothoracic Intersegmental Muscle* (Fig. 20). Homologue of 21. [73].

45. *The Seventh Dorsoventral Muscle of the Mesothorax* (Fig. 21 B). Origin, precoxale; insertion anterior notal wing process. Present only in the male and long winged female. Elevator of the tegmen. [78].

(b) **Noto-coxal.**

38, 38a. *The First and Sixth Dorsoventrals* (Fig. 20). Origin, by two heads from the lateral side of the anterior border of the mesoscutum; insertion by a common tendon into the anterior border of the coxa. The inner belly (38) is broad and stout with parallel fibres, the outer (38a) is slender and conical. The tendon is broad at its base, narrowing into a long linear process. The insertion of 38 is at the broad base of the tendon, that of 38a at the apex of the narrow process (cf. the homologous muscle 59, 59a, Fig. 31). Because of their insertion by a common tendon I have described this muscle and the two following as single muscles. Extensor of the coxa; indirect elevator of the tegmen. [74, 77].

39, 39a. *The Third and Fourth Dorsoventrals* (Fig. 20). The inner head (39) originates in the scutum, not very far from the median line, the outer (39a) near the postero-lateral edge of the scutum above the posterior notal wing process. The tendon, inserted into the posterior side of the coxa, is bilobed, one lobe being broad and short and the other narrow spatulate. 39, a broad, parallel-fibred belly, is attached to the broader lobe, while 39a, a narrow conical belly, is attached to the elongated lobe (cf. 60, 60a, Fig. 30). Voss describes the homologous metathoracic muscles, but states that these muscles are absent in the mesothorax of *Gryllus domesticus*. On the other hand, I have been unable to find his second dorsoventral muscle either in the mesothorax or metathorax of *G. assimilis*. Flexor of the coxa.

(c) **Noto-trochanteric.**

40, (40a). *The Fifth Dorsoventral and the Third Lateral* (Fig. 20). 40 arises in the mesoscutum just laterad of the origin of 39; 40a is a pleuro-pedal muscle originating in the

mesothoracic basalar sclerite. The two bellies enter the coxal cavity where they unite in a common broad flat tendon by which they are inserted into the upper anterior edge of the trochanter. Extensors of the femur; 40a is also an elevator of the tegmen. [76, 81].

PLEURAL MUSCLES.

(a) Pleuro-pedal.

41. *The First (and Second) Lateral Muscle of the Mesothorax* (Fig. 21). From the trochantin by tendon into the basalar sclerite. Usually biceps or digastric. Elevator of the tegmen, also elevator of the coxa. [79, 80].

40a. *The Third Lateral.* See above. [81].

42. *The Fourth Lateral* (Fig. 21). From the upper edge of the mesoepisternum, by tendon into the latero-anterior side of the coxa. Extensor of the coxa. [82].

43. *The Fifth Lateral* (Fig. 22). From the episternum near its middle, into (1) the anterior edge of the coxa, (2) the trochantin, and (3) the precoxale. Extensor of the coxa. [83].

44. *The Sixth Lateral* (Fig. 21). From the postero-lateral edge of the coxa into the subalar plate. Depressor of the tegmen. Flexor of the coxa. [84].

45. (See Tergo-sternals above).

46. (See Sterno-pleurals below).

(b) Noto-pleural.

47. *The Eleventh Lateral Muscle* (Fig. 21). From the anterior side of the pleural wing process into the first intersegmental sclerite. Probably an elevator of the tegmen. [88].

48. *The Twelfth Lateral Muscle* (Fig. 21). From the posterior side of the pleural wing process into a wing axillary just above the subalar plate. A short strong muscle. Depressor of the tegmen. [89].

49. *The Ninth Lateral Muscle* (Fig. 21). From the posterior face of the entopleurite ventrad of the origin of 48, into the posterior notal wing process. A depressor of the tegmen. [86].

(c) Sterno-pleural.

51. *The Lateral Adductor of the Mesothorax* (Fig. 20). From the median entosternite into a small pleural intersegmental sclerite behind the second spiracle. [101].

46. *The Fourteenth Lateral Muscle* (Fig. 21 B). From the precoxale into the basalar sclerite by the same tendon as 38. Found only in the male. Elevator of the tegmen. [91].

LI. *The Furca-entopleural Muscle* (not figured). From the inner sides of the entosternal pocket into the ventral process of the entopleurite. Binds the two processes together. [100].

STERNAL MUSCLES.

Sterno-pedal.

52. *The First Pedal Muscle of the Mesothorax* (Fig. 21). Origin, by three heads from (1) the base of the entosternite, (2 and 3), the sternum immediately in front of the entosternite; insertion into the anterior edge of the coxa. Extensor of the coxa. [93].

LII. *The Seventh Pedal Muscle* (Fig. 21). From the median entosternite, into the posterior edge of the coxa. Flexor of the coxa. [99].

53. *The Second Pedal Muscle* (Fig. 20). From the lateral entosternite above the inner angle of the leg into the posterior edge of the leg adjacent to the insertion of 39. Flexor of the coxa. [94].

54. *The Third Pedal Muscle* (Fig. 21). From the posterior edge of the entosternal pocket into the meso-caudal side of the edge of the coxa. Flexor and adductor of the coxa. [95].

55. *The Fifth Pedal Muscle* (Fig. 21). From the posterior edge of the distal end of the entosternite into the postero-lateral border of the coxa. Adductor of the coxa. [97].

LV. *The Fourth Pedal Muscle* (Fig. 21 B). From the entosternite near the origin of 54, into the trochanter by the same tendon as 40. Extensor of the femur. [96].

C. *The Metathorax.*

LONGITUDINAL MUSCLES.

(a) **Sternal.**

LVI. *The First Metasternal Muscle* (Figs. 20 and 32). Originates from the posterior side of the base of the entosternite near the median line and runs backwards above the first four abdominal sternites. It has three insertions into the lateral end of the anterior edge of the third, fourth and fifth sternites respectively. A ventral retractor of the abdomen. [34].

LVII, LVIIa. *The Second and Third Metasternal Muscles* (Figs. 20 and 32). From the posterior side of the base of the entosternite into the parasternal plate. Depressor of the abdomen. [35].

56. *The Fourth Metasternal* (Fig. 20). From the posterior side of the entosternal pocket, into the parasternal plate. Retractor of the sternum. [36].

(b) **Dorsal.**

57. *The First Metanotal Muscle* (Fig. 20). From the anterior edge of the first abdominal tergite into the entotergite of the metascutum. Parallel and adjacent to the median line. In the long-winged female this muscle is often very strongly developed. (Fig. 28). [37].

DORSOVENTRAL MUSCLES.

(a) **Tergo-sternals.**

58. *The Metathoracic Intersegmental Muscle* (Fig. 20). From the distal end of the entosternite into the first abdominal tergite between the first and second dorsal longitudinal muscles. Homologue of 21 and 37. Rotator of the thorax. [41].

(b) **Noto-coxal.**

59, 59a. *The First and Sixth Dorsoventral Muscles of the Metathorax* (Figs. 20 and 31). Extensors of the coxa. Homologues of 38 and 38a, q. v. [42, 47].

60, 60a. *The Third and Fourth Dorsoventrals* (Figs. 20 and 30). Flexors of the coxa. Homologues of 39, 39a, q. v. [44, 45].

(c) **Noto-trochanteric.**

61, (61a). *The Fifth Dorsoventral and the Third Lateral* (Figs. 20 and 29). Extensors of the femur. See 40, 40a. [46, 50].

PLEURAL MUSCLES.

(a) **Pleuro-pedal.**

61a. See above. [50].

62. *The First and Second Lateral Muscles of the Metathorax* (Fig. 21). See 41. Elevator of wing. [48, 49].

63. *The Fourth Lateral* (Fig. 21). Homologue of 42 q. v. [51].

64. *The Fifth Lateral* (cf. Fig. 22). The Homologue of 43. The precoxale is not developed as a separate sclerite in the metathorax, so this muscle has but two insertions, into the trochantin and the coxa. [52].

65. *The Sixth Lateral* (Fig. 21). Homologue of 44. This muscle is inserted quite distinctly into the coxa and not into the epimeron as is the case in *G. domesticus* (Voss). Depressor of the wing. [53].

(b) **Noto-pleural.**

66. *The Seventh Lateral* (Fig. 21). Origin, from the epimeron, a short distance dorsad of its middle; insertion, into the posterior subalar plate. Depressor of the wing. [54].

67. *The Twelfth Lateral* (Fig. 21). The homologue of 48 q. v.

68. *The Eleventh Lateral* (Fig. 21). From the anterior side of the pleural wing process into the anterior angle of the base of the wing, just in front of the anterior notal wing process. Elevator of the wing. [58].

(c) **Sterno-pleural.**

LXVIII. *The Furca-entopleural Muscle of the Metathorax* (Not figured). Homologue of LI, q. v.

STERNAL MUSCLES.

Sterno-pedal.

69. *The First Pedal Muscle of the Metathorax* (Fig. 20). From the anterior side of the base of the entosternite into the inner anterior edge of the coxa. Adductor and extensor of the coxa. [60].

70. *The Second Pedal Muscle* (Fig. 20). Homologue of 53, q. v. [61].

71. *The Third Pedal Muscle* (Fig. 21). Homologue of 54. [62].

72. *The Fifth Pedal Muscle* (Fig. 21). Homologue of 55. [64].

LXXII. *The Fourth Pedal Muscle* (Not figured, cf. Fig. 21B, LV). Homologue of LV.

THE MUSCLES OF THE LEGS.

(Plate V.)

The various muscles of the coxa as well as the large extensors of the femur which originate in the thorax have already been described. The following muscles lie entirely within the leg segments.

(a) Coxo-trochanteric Muscles.

The First Intracoxal Extensor of the Femur (Figs. 23 and 25, 1 ext. fem.) is a stout muscle with slightly converging fibres. It originates from the anterior side of the basal border of the coxa and is inserted into the trochanter just in front of the insertion of the large noto-trochanteric extensors.

The Second Intracoxal Extensor of the Femur (Figs. 23 and 25, 2 ext. fem.) is a conical muscle originating from the ventral edge of the base of the coxa and inserted by the same tendon as the noto-trochanteric extensors into the ventral edge of the trochanter.

The Third Intracoxal Extensor of the Femur (Figs. 23 and 26, 3 ext. fem.) originates from the posterior face of the coxa and is inserted into the trochanter behind the insertion of the noto-trochanteric extensor.

The First Flexor of the Femur (Figs. 23 and 26, 1 fl. fem.) originates in the dorsal edge of the coxa, and in the first and second legs, is inserted by a tendon into the dorsal edge of the base of the trochanter. In the hind legs it is inserted into the base of the femur at the dorsal edge of the femoral opening.

The Second Flexor of the Femur (Figs. 24 and 26, 2 fl. fem.) is similar to the first in its insertion. In the pro- and mesothoracic legs this flexor is a simple conical muscle, originating from the ventral side of the basal end of the coxa and running diagonally across the coxa. In the metathoracic leg the second flexor is a more powerful multiceps muscle. One head originates from the posterior face of the coxa, one from the ventral edge of the anterior face, and three from the basal edge of the anterior face.

(b) Trochantero-femoral Muscles.

The Fourth Extensor of the Femur (Fig. 25, 4 ext. fem.) is a small muscle originating from the ventral side of the base of the trochanter and inserted into the ventral side of the base of the femur.

The Anterior Flexor of the Femur (Fig. 26, ant. fl.) is a broad flat muscle with parallel fibres. It originates from the basal edge of the anterior face of the trochanter and is inserted into the anterior face of the femur. These two muscles are not present in the small trochanter of the hind legs.

(c) Femoro-tibial Muscles.

The Extensor of the Tibia (Figs. 23 and 25, ext. tib.) In the large leaping hind leg this muscle originates from the entire dorsal two-thirds of the inner surface of the femur. It is a pseudo-penniform muscle sending short oblique fibres into the long spatulate tendon by which it is inserted into the dorsal edge of the base of the tibia.

In the first and second legs (Fig. 25, ext. tib.) the extensor is much weaker. The tendon is shorter and the fibres originate chiefly from the basal end of the femur, though some spring from near or beyond the middle of the segment.

The Flexor of the Tibia (Figs. 23 and 25, fl. tib.) originates by two heads from (1) the ventral side of the base of the trochanter and (2) the proximal end of the ventral side of the femur. It is a conical muscle and is inserted into the ventral proximal edge of the tibia by means of a long linear tendon.

(c) Tibio-tarsal Muscles.

The First Extensor of the Tarsus (Fig. 23, 1 ext. tar.) is very similar to the extensor of the tibia in the hind leg. It lies in the ventral half of the tibia, and is inserted into the proximal end of the first tarsal segment.

The Second Extensor of the Tarsus (Fig. 23, 2 ext. tar.) originates from the dorsal side of the tibia near the femoro-tibial articulation. It is a short conical muscle and is inserted by a long filamentous tendon, running through the greater part of the tibia and tarsus, into the ventral edge of the third tarsal segment.

The second tarsal segment, projecting as it does backwards and forwards beneath the first and third, limits the flexing of the tarsal segments, so that this muscle extends the entire tarsus outwards in a straight line with the tibia.

The Flexor of the Tarsus (Fig. 23, fl. tar.) originates in the dorsal face of the tibia a short distance from the articulation with the femur. It is inserted by a flat tendon into the first tarsal segment.

(d) Tarsal Muscles.

The Extensor of the Second and Third Tarsal Segments (Fig. 23, ext. tar.$_2$) lies in the dorsal side of the first tarsal segment. It originates in the proximal end of the segment and is inserted into the dorsal proximal edge of the second segment. When this last is extended it pulls the third segment with it so that the two segments move together.

The Extensor of the Claws (Fig. 23, ext. ung.) originates from the proximal end of the dorsal side of the third tarsal segment and is inserted into the base of the claws by means of a tendon, which forms a bridge between them on the dorsal side.

The Flexor of the Claws (Figs. 23 and 27, fl. ung.) originates on the ventral side of the third segment opposite the origin of the extensor. Connected with the base of the claws on the ventral side is a prominent apodeme (Fig. 27, ap. ung.) at the end of which the flexor is inserted by a long narrow tendon.

IV. MUSCLES OF THE ABDOMEN.

(Plate VI, Figs. 32–36.)

A. First Abdominal Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

73. *The First Ventral Muscle* (Fig. 32). From near the antero-lateral edge of the first sternite, into the anterior edge of the second sternite. [26].

74. *The Second Ventral* (Fig. 32). From the lateral side of the first sternite into the inner angle of the parasternal plate. [27].

(b) Tergal.

75. *The First Dorsal Muscle* (Fig. 32). Two straight flat muscles lying in the tergum near the median line. They originate from the posterior edge of the tergite and are inserted into the anterior edge of the second tergite. [28].

76. *The Second Dorsals* (Fig. 32). Origin contiguous to that of 75; inserted into the lateral end of the anterior edge of the second tergite. [29].

The longitudinal muscles are retractor muscles of the abdomen.

DORSOVENTRAL MUSCLES.

Tergo-sternal.

77. *The Second Dorsoventral* (Fig. 32). From the lateral edge of the tergite near the posterior end, into the lateral angle of the parasternal plate. [31].

PLEURAL MUSCLES.

Sterno-pleural.

78. *The Dilator of the Spiracle* (Fig. 32). From the lateral end of the anterior edge of the parasternal plate into the closing lever or process of the stigmatal bow. [32, Lateral stigmatal muscle α].

79. *The Second Dilator of the Spiracle* (Fig. 32) originates with 78 from the parasternal plate and is inserted into the pleural membrane just behind the spiracle. Present only in the first and second abdominal segments. [32, Lateral stigmatal muscle β).

B. The Second Abdominal Segment.

TRANSVERSE MUSCLES.

Sternal.

80. *The Ventral Transverse Muscle* (Fig. 32). From the middle of the parasternal plate of one side across the anterior end of the second sternite into the parasternal plate of the other side. [17].

LONGITUDINAL MUSCLES.

(a) **Sternal.**

81. *The First Ventral Muscle* (Fig. 32). From behind the anterior margin of the second sternite into the anterior margin of the third sternite. [13].

82. *The Second Ventral Muscle* (Fig. 32). From the mesal edge of the parasternal plate, into the anterior edge of the third sternite. [14].

(b) **Tergal.**

83. *The First Dorsal Muscles* (Fig. 32). Homologous with 75 and similarly arranged.

84. *The Second Dorsal Muscles* (Fig. 32). Homologous with 76, but originate near the transverse medial line and not in the anterior margin of the second tergite.

DORSOVENTRAL MUSCLES.

Tergo-sternal.

85. *The First Dorsoventral Muscle* (Fig. 32). From the anterior end of the lateral edge of the tergite into the parasternal plate immediately behind the insertion of the tergosternal of the first segment. [30].

As stated before, the musculature of the parasternal plate indicates that this sclerite is composed of detached portions of the first and second sternites. Muscles 56, LVII, 74, 77, 78 and 79 appear to belong to the first sternite, while the others belong to the second. Voss, however, described 85 as an intersegmental muscle, a mistake no doubt due to the fact that the anterior tergosternals not being developed in any other segment in *G. domesticus*, he failed to trace the homology.

86. *The Second Dorsoventral* (Fig. 32). A straight parallel-fibred muscle originating from the posterior end of the lateral edge of the tergite and inserted into the corresponding region of the sternite. [18].

PLEURAL MUSCLES.

(a) **Noto-pleural.**

87. *The Fourth Lateral Muscle* (Fig. 32). From the postero-lateral angle of the tergite into the posterior pleural sclerite of the second segment. [22].

88. *The Fifth Lateral Muscle* (Fig. 32). Origin as in 87; insertion into the first pleural sclerite of the third segment. [23].

(b) **Sterno-pleural.**

89. *The First Lateral Muscle* (Fig. 32). From the parasternal plate into the pleural membrane in front of the spiracle. Voss regards this as the first and second laterals. The large third pleural sclerite (ps_3) of the third segment probably results from the fusion and enlargement of the sclerites of the second and third segments, in which case 92 is probably the homologue of the second lateral of the succeeding segments and I have thus regarded it. [19, 20].

90, 91. *The Dilators of the Spiracles* (Fig. 32). Homologues of 78 and 79, and similarly placed. [25, lateral stigmatal α and β].

92. *The Second Lateral* (Fig. 32). From the parasternal plate into the antero-ventral edge of the third pleural sclerite of the third segment. [24, sixth lateral parastigmatal].

93. *The Third Lateral* (Fig. 32). From the parasternite into the second pleural sclerite of the second segment.

C. The Third to Sixth Segments of the Female; Third to Eighth of the Male.

TRANSVERSE MUSCLES.

Sternal.

94. *The Transverse Ventral Muscle* (Fig. 32) lies entirely within the sternum across the anterior end. Its points of attachment are near the latero-anterior angles of the sternite.

LONGITUDINAL MUSCLES.

(a) **Sternal.**

95. *The First Ventral Muscle* (Fig. 32). A short muscle having its origin near the transverse median line and lying not far from the longitudinal median line of the sternite. It is inserted into the anterior border of the segment behind the one in which it lies. [1].

96. *The Second Ventral Muscle* (Fig. 32) lies in the lateral side of the sternum and extends from the anterior border of one segment to the anterior border of the next segment behind. [2].

(b) **Dorsal.**

83, 84. *The First and Second Dorsals.* (See above).

DORSOVENTRAL MUSCLES.

Tergo-sternal.

97. *The First Dorsoventral Muscle* (Fig. 32) stretches across the pleural membrane from the antero-lateral angle of the tergite to the corresponding region of the sternite. Homologue of 85.

98. *The Dorsoventral Sternal* (Fig. 32). Homologue of 77 and 86. Similar to 97, but lying in the posterior end of the segment. [5].

PLEURAL MUSCLES.

(a) Noto-pleural.

99. *The Fourth Lateral Muscle.* Homologue of 87, q. v. [9].
100. *The Fifth Lateral.* Homologue of 88, q. v. [10].

(b) Sterno-pleural.

The sternopleural muscles (101 to 105) all originate from the lateral border of the sternite in succession from the anterior to the posterior end of the sclerite. They are inserted into the pleural sclerites or into the spiracle, as follows:

101. *The First Lateral*, into the first pleural sclerite. [6].
102. *The Second Lateral*, into the third pleural sclerite. [7].
103. *The Dilator of the Spiracle*, into the process of the bow of the spiracle. [11].
104. *The Third Lateral*, into the second pleural sclerite. [8].
105. *The Third (a) Lateral*, with 104 into the second pleural sclerite.

Functions of the Foregoing Abdominal Muscles. The longitudinal muscles are retractors of the abdomen. The ventral and dorsal working together telescope the segments. The ventral bend the body downwards, while the dorsal act as their antagonist muscles, bending the body upwards. The tergo-sternals and laterals are expiratory muscles, and pull the sternum and tergum together. Those of either side working alone may act as rotators of the abdomen.

THE EXTREMITY OF THE ABDOMEN.

In both sexes ten dorsal segments, including the suranal plate (Figs. 3, 33, 35, P. S.) can be readily distinguished. On the ventral side, however, there are only eight in the female and nine in the male, including the subgenital plate. A study of the musculature as described below will show, apart from other evidence, that in the female the supra-genital plate, lying above the ovipositor is the sternite of the ninth segment, and in both sexes the podical plates (P. P.) are the divided halves of the tenth sternite.

D. The Seventh Abdominal Segment of the Female.

LONGITUDINAL MUSCLES.

Sternal.

106. *The Retractor of the Vagina* (Fig. 33) is a flat parallel-fibred muscle originating from the antero-lateral angle of the seventh sternite and inserted into the dorsal side of the vagina at its junction with the oviduct. A suspensor and retractor of the vagina. The muscle probably helps to force the egg out by elongating the vagina, thus reducing its lumen and exerting pressure on the egg.

107. *The Adductor of the Subgenital Plate* (Figs. 33 and 34). A rectus muscle having its origin adjacent to and immediately in front of 106. It is inserted into the lateral end of the anterior border of the eighth sternite or subgenital plate. Homologous with the second sternals.

The other muscles are similar to those of the preceding segments.

E. The Eighth Segment in the Female.

LONGITUDINAL MUSCLES.
(Fig. 34.)

There are no longitudinal muscles in the eighth sternites. The tergal muscles occupy the entire tergum except the median line, and all extend from the anterior to the posterior border, showing no differentiation between the first and second dorsals.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

108. *The Abductor of the Subgenital Plate* (Fig. 34) originates from the lateral end of the anterior process of the eighth tergite, runs obliquely ventrad, and is inserted into the antero-lateral angle of the subgenital plate.

(b) Noto-gonapophysal.

109. *The First Depressor of the Ovipositor* (Fig. 33) is a large, strong, conical muscle originating from the inner face of the anterior process of the eighth tergite and running obliquely ventrad to be inserted into the ventral process of the ventral gonapophysis.

F. The Ninth Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

110. *The Second Ventral* (Fig. 35). A rectus muscle from the anterior lateral angle of the subgenital plate, the ninth sternite, into the ventral edge of the podical plate or tenth tergite. This muscle apparently enlarges the anal opening. Found in the male only.

(b) Tergal.

Similar to the eighth segment.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

111. *The Indirect Elevator of the Ovipositor* (Fig. 34). A straight muscle from the anterior edge of the ninth tergite into the supragenital plate or ninth sternite.

(b) Noto-gonapophysal.

112. *The Second Depressor of the Ovipositor* (Figs. 33 and 34), is a strong muscle originating from the entotergite of the ninth segment. It is inserted into (1) the ventral process of the dorsal gonapophysis and (2) the median process of the transverse beam connecting the ventral processes of the two dorsal gonapophyses.

113. *The Third Depressor of the Ovipositor* (Fig. 33), a stout, conical muscle, also originates from the inner face of the anterior process (entotergite) of the ninth tergite. It lies on the inner side of the second depressor and is inserted into the ventral process of the dorsal gonapophysis.

114. *The First Elevator of the Ovipositor* (Figs. 33 and 34), is a short broad muscle originating from the lateral anterior edge of the ninth tergite and inserted into the ventral face of the dorsal process of the dorsal gonapophysis.

STERNAL MUSCLES.

(a) Male Genital Muscles.

115. *The Suspensory Muscle of the Spermatophore Cup* (Figs. 35 and 36), a short muscle from the latero-anterior angle of the subgenital plate into the ventral valve of the spermatophore cup at its junction with the ductus ejaculatorius.

116. *The First Retractor of the Spermatophore Cup* (Figs. 35 and 36) originates from the anterior end of the ventral valve at its junction with the ductus, runs obliquely round the cup and is inserted into the lateral side of the dorsal valve at the posterior end where the chitinous plates are given off.

117. *The Second Retractor of the Spermatophore Cup* (Figs. 35 and 36) is similar to the first retractor in origin and insertion and lies between it and the cup.

118. *The Dilator of the Mouth of the Spermatophore Cup* (Figs. 35 and 36), a very short, straight muscle having its origin on the dorsal side of the dorsal valve and its insertion adjacent to that of the retractors.

119. *The Constrictor of the Spermatophore Cup* (Figs. 35 and 36) forms a muscular tunic covering the outer surface of the dorsal valve of the spermatophore cup. The action of this muscle and of the retractors forces the spermatophore out of the cup.

(b) **Female Genital Muscles.**

120. *The Protractor of the Ovipositor* (Fig. 33) is a short, stout muscle which originates from the process of the supra-genital plate (P. S. G.) and is inserted into the inner face of the ventral process of the dorsal gonapophysis. Pulls the ovi-positor backwards.

121. *The Lateral Abductor of the Gonapophyses* (Fig. 33) also originates from the supragenital process and is inserted into the dorsal process of the ventral gonapophysis. It pulls the two gonapophyses of one side apart from those of the other side, at the same time enlarging the genital orifice which lies between the bases of the ventral gonaphyses. It also elevates the ovipositor.

THE MECHANICS OF THE OVIPOSITOR.

The two plates on each side are enabled to work together (1) by a tongue and groove joint which runs along their entire length and (2) by the interlocking of the dorsal processes. (Fig. 3).

The ovipositor is a lever of the first order, the inner processes being the force arms, so that an upward or downward pull on these processes, respectively depresses or elevates the external plates. Similarly an inward pull (the transverse beam being the fulcrum in this case) separates the right and left plates externally.

G. The Tenth Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

122. *The Ventral Muscle* (Fig. 35) is a short flat muscle lying across the inner end of the pedical plate. Probably the homologue of the first ventral muscle of the anterior segments.

(b) Tergal.

123. *The Dorsal Muscle* (Fig. 35), a homologue of the first dorsals of the anterior segment lies near the median line of the suranal plate, stretching from the anterior to the posterior borders of the sclerite. This and the preceding pull the edges of the anus forward, probably aiding in the ejection of the faeces.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

124. *The First Dorsoventral* (Fig. 35). From the lateral side of the anterior edge of the suranal plate into the anterior edge of the podical plate near the insertion of the first ventral of the ninth segment. Pulls down the podical plate, enlarging the anal orifice.

125. *The Second Dorsoventral* (Fig. 35). From near the hinder end of the suranal plate into the podical plate a short distance in front of its hinder border. Closes the anal orifice by bringing the edges of the suranal and podical plates together.

(b) Noto-cercal.

126. *The Adductor of the Cercus* (Figs. 34 and 35). From the median line of the suranal plate into the inner side of the base of the cercus.

127. *The Depressor of the Cercus* (Figs. 34 and 35). From the anterior edge of the suranal plate into the ventral side of the base of the cercus.

128. *The Elevator of the Cercus* (Figs. 34 and 35) originates laterad of the origin of the depressor and is inserted into the dorsal edge of the cercus.

129. *The Abductor of the Cercus* (Figs. 34 and 35). From the anterior edge of the lateral portion of the suranal plate into the outer edge of the cercus.

V. THE MUSCLES OF THE SPIRACLES.

THE MESOTHORACIC SPIRACLE (Fig. 37) lies transversely in the pleural membrane behind the prothoracic leg. The anterior lip is composed of a broad ventral (a. $l._1$) and a narrow dorsal (a. $l._2$) sclerite. Two tracheal chambers open into the vestibule and between the two chambers there is a thickened chitinous septum (c. t.)

The First Occlusor of the Mesothoracic Spiracle (Fig. 37, $oc._1$ sp.) originates near the anterior margin of the episternum of the mesothorax and is inserted into the ventral anterior valve. It closes the orifice of the spiracle by pulling the anterior lip against the posterior.

The Second Occlusor of the Mesothoracic Spiracle (Fig. 37, $oc._2$ sp.) originates from the ventral sclerite of the anterior lip and is inserted into the anterior side of the chitinous septum between the two tracheal chambers. It closes the dorsal chamber by pulling its anterior and posterior walls together. There seems to be no mechanism for closing the ventral chamber apart from the first occlusor.

THE METATHORACIC SPIRACLE (Figs. 38 and 39) has a crescent shaped anterior lip (a. l.) and a somewhat sickle-shaped posterior lip (p. l.) with an expanded ventral end. There is but one tracheal chamber, the ventral wall of which has a chitinous thickening which serves for the insertion of an occlusor muscle.

The First Occlusor of the Metathoracic Spiracle (Fig. 38, $oc._1$ sp.) originates from the outer border of the posterior lip and is inserted into the anterior lip. It closes the spiracle by pulling the two valves together.

The Second Occlusor of the Metathoracic Spiracle (Fig. 39, $oc._2$ sp.) has the same origin as the first, but is inserted into the chitinous thickening of the wall of the tracheal chamber. It closes the chamber by pulling its walls together.

THE ABDOMINAL SPIRACLES (Figs. 40 and 41) have a triangular posterior valve and an arcuate anterior valve. Each valve bears a narrow ridge beset with minute chitinous projections. The ridge of the anterior segment is the "bow" of Landois, and bears near its ventral end an inward projecting process, the closing lever or peg.

The Occlusor of the Abdominal Spiracles (Figs. 40 and 41, oc. sp.) is a short muscle which takes its origin from the dorso-posterior edge of the triangular posterior valve. It is inserted into the process of the bow and closes the spiracle by pulling the bow down against the other lip.

The Dilator Muscle (Figs. 40 and 41, d. sp., Fig. 32, 103) originates from the lateral edge of the abdominal sternite and is inserted into the extreme ventral end of the closing lever.

VI. THE MUSCLES OF THE VISCERA.

The Constrictor Muscles of the Oesophagus and Crop form a muscular tunic composed of a single layer of circular muscles.

The Constrictor Muscles of the Proventriculus (Fig. 42, c. m.) form a very strong muscular coat consisting in its thickest part of as many as ten layers of circular muscles.

The Dilator Muscles of the Proventriculus (Fig. 42, d. m.) are situated within the cavity of each median tooth. The edges are attached at the bases of the outer barbated lobes near the partitions between the epithelial folds. The muscle folds on itself, the fold extending far within the cavity of the median tooth. The effect of the contraction of this peculiar muscle is to pull the epithelial folds outwards towards the muscular tunic, thus enlarging the lumen of the proventriculus.

The Constrictors of the Mesenteron form a single layer of circular muscles.

The Dilators of the Mesenteron are longitudinal muscles, several groups of which lie along this organ outside the circular muscles.

The Constrictors of the Rectum (Figs. 43 and 44, c. m.) are usually two layers thick.

The Dilators of the Rectum (Figs. 43 and 44, d. m.) There are six groups of dilator muscles in the rectum, which originate from the body wall as follows: The two dorsals from the anterior edge of the tenth tergite, one on each side of the median line; the two laterals from the lateral side of the anterior edge of the same sclerite, in front of the cerci; the two ventrals in the male from the latero-anterior processes of the eighth sternite, in the female from the base of the ventral gonapophyses in the angle between the ventral and dorsal processes. Each of these groups

enters the rectum, behind its middle, on the line where the primary epithelial folds are in contact with the muscular tunic. The muscles of each group then separate, running backwards and forwards along this line and extending from the anus to the junction of the colon and rectum.

The Suspensorium of the Crop and Gastric Caecum is a thin muscle originating from the anterior border of the pronotum near the median line. One branch enters the latero-dorsal wall of the crop near its middle and runs backwards towards the proventriculus; another branch is inserted at the apex of the caecum and divides into several smaller bundles which run backwards, forming the longitudinal muscles of the caecum.

The Alary Muscles of the Heart. There are ten of these delicate fan-shaped muscles, one in the mesothorax, one in the metathorax, and one in each of the eight anterior abdominal segments. They originate in the dorsal diaphragm near the median line beneath the heart, and are inserted near the lateral end of the anterior border of the several tergites.

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REFERENCE LETTERING.

A_1, A_2, etc.—Abdominal segments.
Abd.—Abductor muscle.
Ad.—Adductor Muscle.
A. L.—Lateral apodeme of the dorsal border of the occipital foramen.
a. l.—Anterior valve of the spiracle.
A. M.—Median dorsal apodeme of the base of the head.
a. n. p.—Anterior notal wing process.
ant.—Antenna.
ant. fl.—Anterior flexor of the femur.
ap.—Apodeme.
b. s.—Basalar sclerite.
C_1, C_2.—Cardo, first and second segments.
Cerv.—Veracervix or neck region.
c. hyp.—The compressor of the hypopharynx.
c. m.—Constrictor (circular) muscles of the digestive tract.
Cox.—Coxa.
Cs.—Cercus.
c. t.—Chitinous thickening of the tracheal wall.
d_1, d_2.—Internal dorsal processes of the dorsal and ventral gonapophyses respectively.
dep.—Depressor muscle.
d. m.—Dilator muscle.
d. sp.—Dilator of the spiracle.
el.—Elevator muscle.
Em.—Epimeron.
Ep.—Episternum.
ep.—Entopleurite.
Eph.—Epipharynx.
eph. m.—Epipharyngeal muslce.
es.—Lateral entosternite (furca).
es. m.—Median entosternite (spina).
ext.—Extensor muscle.
ext. a. s.—Extensor of the antennal segment.
ext. p. s.—Extensor of the palpal segment.
F. A.—Anterior foramen of head.
fem.—Femur.
F. L.—Lateral foramen of head.
fl.—Flexor muscle.
fl. a. s.—Flexor of the antennal segment.
fl. g.—Flexor of the galea.
fl. p.—Flexor of the palpus.
fl. p. s.—Flexor of the palpal segment.
F. O.—Occipital foramen.
Fs.—Furcasternite.
G.—Gena.
Gal.—Galea.
G. D.—Dorsal gonapophysis.
Gl.—Glossa.
G. V.—Ventral gonapophysis.
hyp.—Hypopharynx.
in_1, in_2.—Intersegmentalia.
i. p.—Interpleurite of the veracervix.
i. st.—Intersternites of the veracervix.
i. tg.—Intertergites of the veracervix.
Lac.—Lacinia.
Lb, lb.—Labium.
Lbr., lbr.—Labrum.
l. d.—Lateral dilator of the oesophagus.
m. ant.—Antennal muscles.
Md., md.—Mandible.
Mx., mx.—Maxilla.
Oc.—Ocellus.
oc.—Occlusor muscle.
Oes.—Oesophagus.
P. A_8, P. A_9—Anterior tergal processes (entotergites) of the eighth and ninth abdominal segments.
Pcx.—Precoxale.
P. G.—Postgena.
Pgl.—Paraglossa.
Ph.—Pharynx.
p. l.—Posterior valve of spiracle.
Pl. mb.—Pleural membrane.
p. n. p.—Posterior notal wing process.
P. P.—Podical plate.
p. p.—Pleural wing process.
pr. d.—Precerebral dilators of oesophagus and pharynx.
P. S.—Suranal plate.
p. s.—Pleural sclerites of abdomen.
Pscl.—Postscutellum.
P. S. G.—Process of the supragenital plate.
ps. p.—Parasternal plate.
pst. d.—Postcerebral dilators of the oesophagus.
r. hyp.—Retractor of the hypopharynx.
r. lb.—Retractor of the labium.
sa. p.—Subalar plate.
Sc.—Scutum.
Scl.—Scutellum.
sp.—Spiracle.
sp. c.—Spermatophore cup.
Ss.—Spinasternite.
st.—Stipes.
Stn.—Sternum.
t.—Tendon.
T. A.—Anterior arm of the tentorium.
tar.—Tarsus.
T. C.—Central plate of tentorium.
t. c.—Transverse chitinous beam connecting the ventral processes of the two dorsal gonapophyses.
tend.—Tendon.
Tg.—Tergite.
tib.—Tibia.
T. P.—Posterior arm of tentorium.
tr.—Trochantin.
Troc.—Trochanter.
ung.—Claws.
v_1, v_2—Internal ventral processes of the dorsal and ventral gonapophyses, respectively.
vag.—Vagina.
vd.—Ventral dilators of the oesophagus.
Vs.—Verasternite.

EXPLANATION OF FIGURES.

Plate I.

Fig. 1. Plan of part of the inner right side of the skeleton showing the endoskeletal structures and the attachment of the muscles. External sclerites are dotted, the internal sclerites and processes are shaded black, tendons are cross-hatched and the attachment of the muscles outlined with dotted lines.

Plate II.

Fig. 2. Ventro-caudal view of the epicranium showing the tentorial plates.
Fig. 3. Inner view of the right half of the extremity of the female abdomen.
Fig. 4. The mandibles and their muscles. On the left side several layers of the adductor are removed to show the tendons, on the right side the adductor is cut across to show its thickness.
Fig. 5. Front view of the head with the labrum, clypeus and front removed to show the heads of the adductors of the mandibles, the anntenal muscles and the dilators of the oesophagus and pharynx.
Fig. 6. Longitudinal section through the head.
Fig. 7. The muscles of the labrum.
Fig. 8. Longitudinal section through the lateral side of the labrum, clypeus and part of the front.
Fig. 9. Same through the median line.
Fig. 10. Longitudinal section through the basal joints of the antenna.
Fig. 11. Portion of front of head showing the antennal muscles.

Plate III.

Fig. 12. Head with the greater part of the epicranium and internal tissues removed to expose the muscles of the maxillae.
Fig. 13. Ventro-caudal view of the head with the labium and gular region removed.
Fig. 14. Muscles of the maxilla.
Fig. 15. External muscles of the maxilla.
Fig. 16. Caudal view of the head with the integument of the mentum and submentum removed exposing the labial and maxillary muscles.
Fig. 17. The muscles of the labium.
Fig. 18. The cervical muscles.
Fig. 19. External cervical muscles.

Plate IV.

Fig. 20. The inner layer of thoracic muscles, right side.
Fig. 21. (A) The outer layer of thoracic muscle. (B)* The outer layer of the mesothoracic muscles of the male.

Plate V.

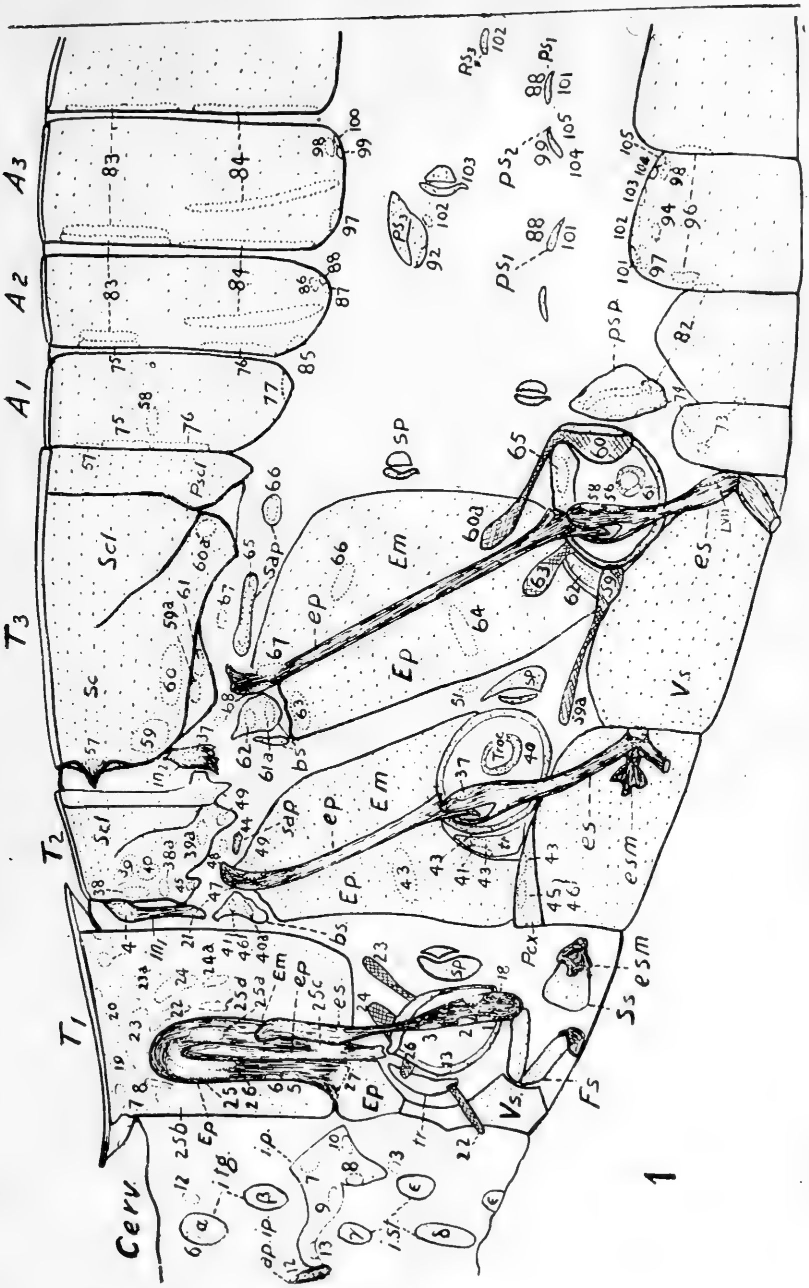
Fig. 22. The articulation of the mesothoracic leg with the episternum and the sternum showing the fifth lateral muscle of the mesothorax.
Fig. 23. Inner side of the anterior face of the right metathoracic leg.
Fig. 24. Anterior face of the coxa of metathoracic leg with the extensors of the femur removed to show the flexors.
Fig. 25. Anterior face of left mesothoracic leg.
Fig. 26. Posterior face of the coxa and trochanter of the same.
Fig. 27. Ventral view of the claws and their flexing apparatus.
Fig. 28. Enlarged metathoracic longitudinal dorsal muscle of longwinged female.
Fig. 29. The nototrochanteric extensor of the femur.
Fig. 30. The notocoxal flexor.
Fig. 31. The notocoxal extensor.

PLATE VI.

Fig. 32. The muscles of the first five abdominal segments. In segments 3 and 4 the dorsoventrals are removed to expose laterals.
Fig. 33. Muscles of the extremity of the female, inner layer.
Fig. 34. Same, outer layer.

PLATE VII.

Fig. 35. Muscles of the extremity of the male.
Fig. 36. Lateral view of the spermatophore cup and its muscles.
Fig. 37. Inner view of the mesothoracic spiracle.
Fig. 38. Inner view of the metathoracic spiracle.
Fig. 39. Same with the first occlusor removed.
Fig. 40. Inner view of an abdominal spiracle, open.
Fig. 41. Same, closed.
Fig. 42. Transverse section through one fold of the proventriculus.
Fig. 43. Transverse section of the rectum.
Fig. 44. External view of the rectum.



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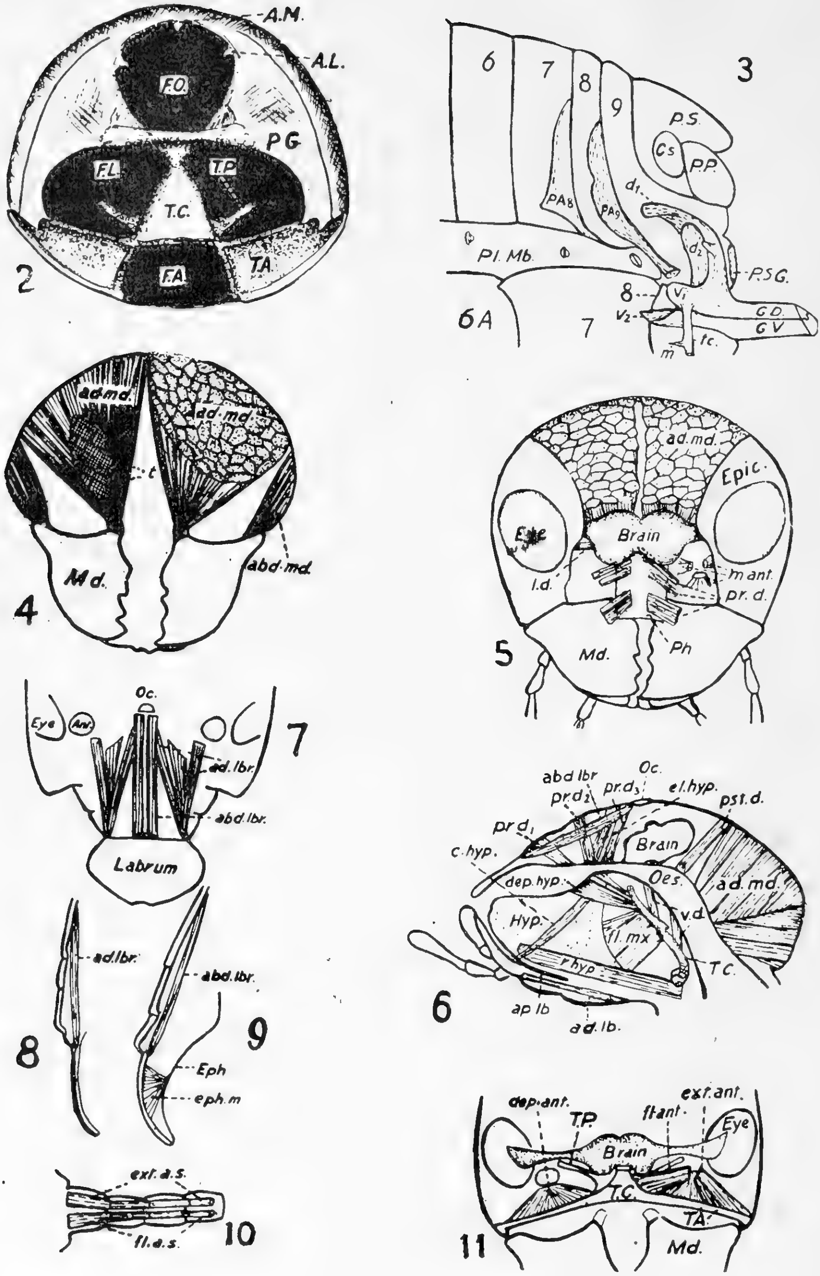
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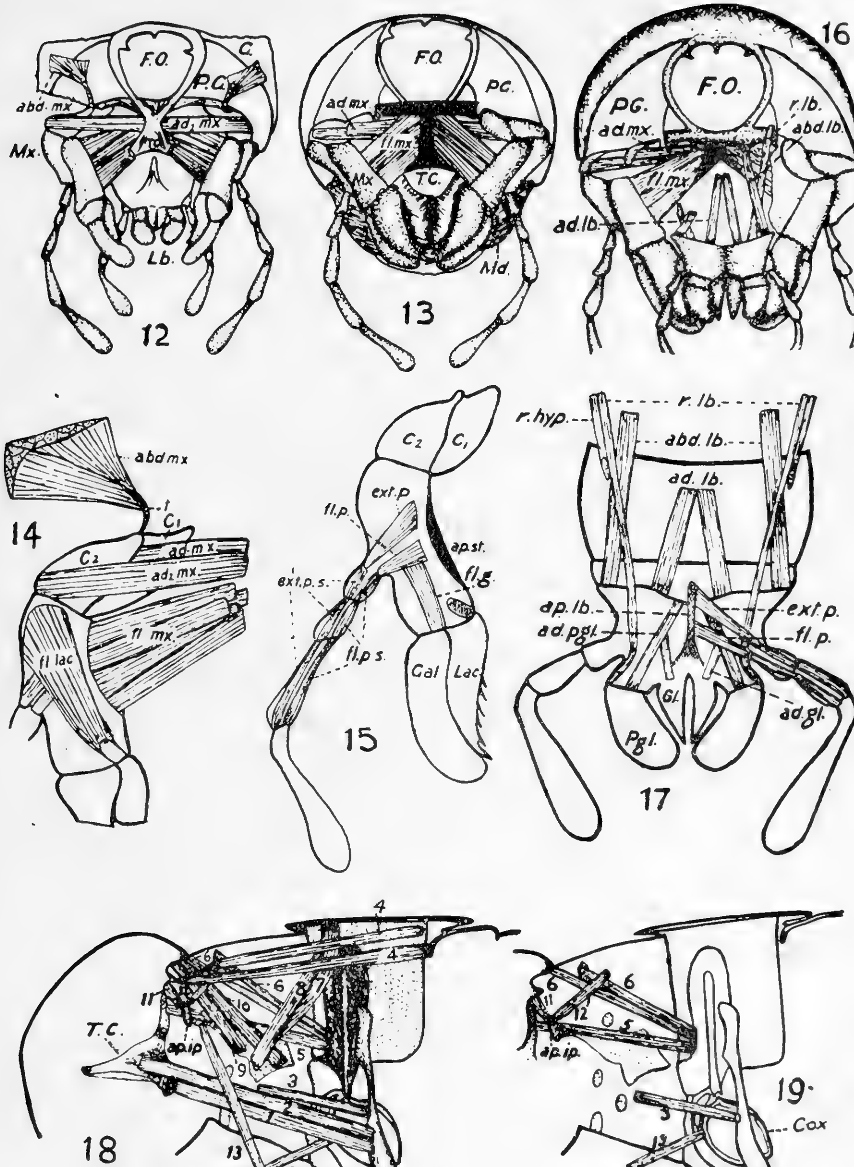
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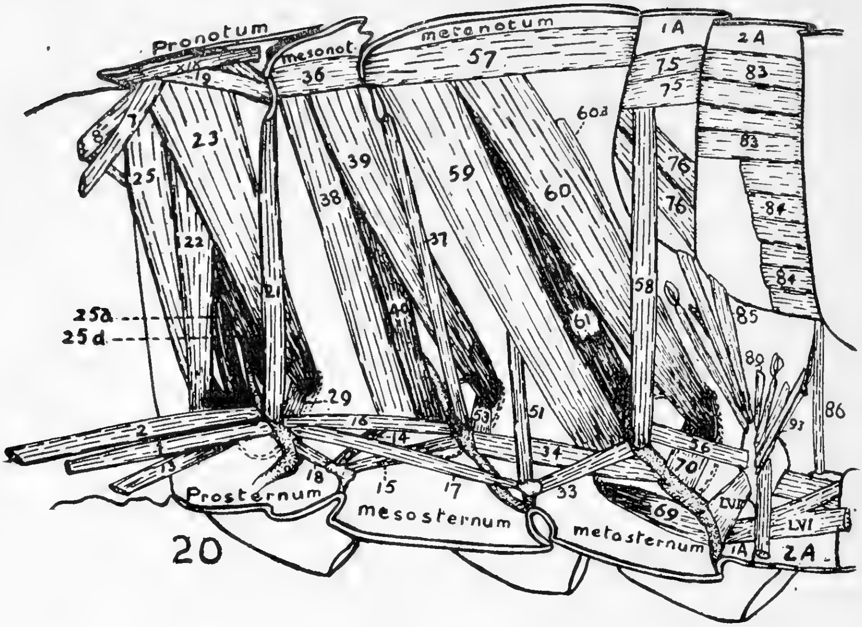

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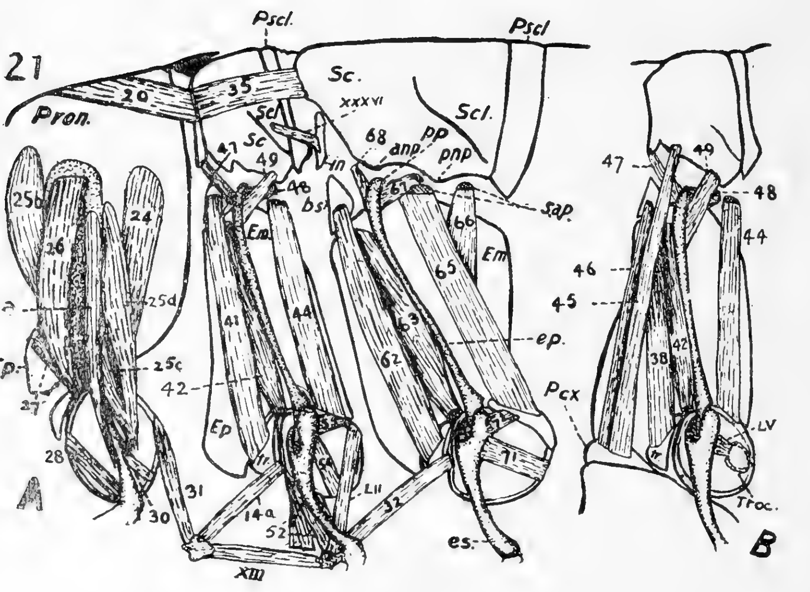

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(NOTE—In Figure 21B for 38 read 41.)

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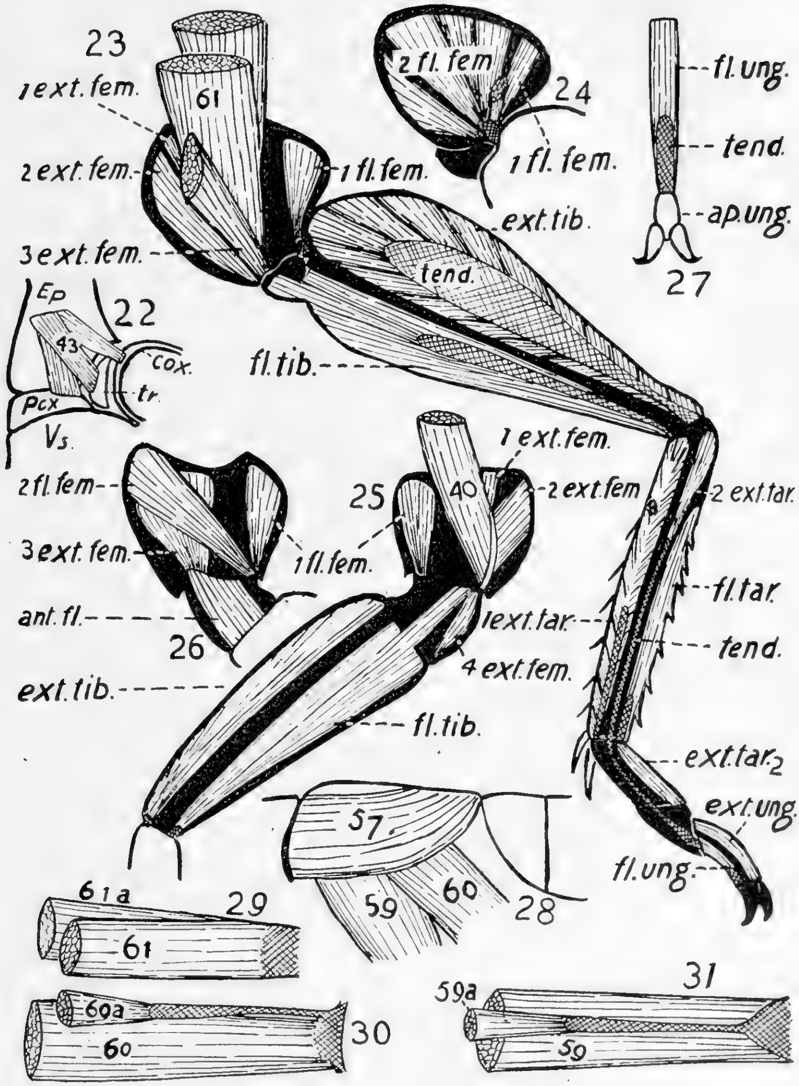

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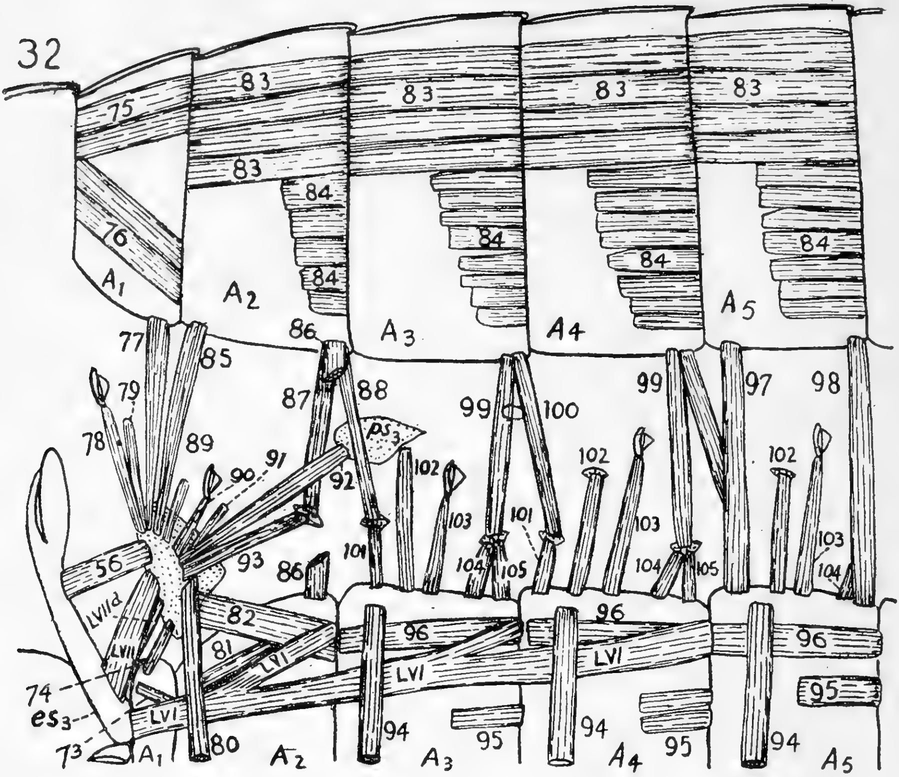

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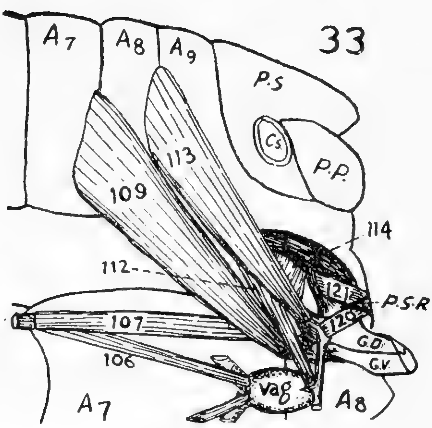

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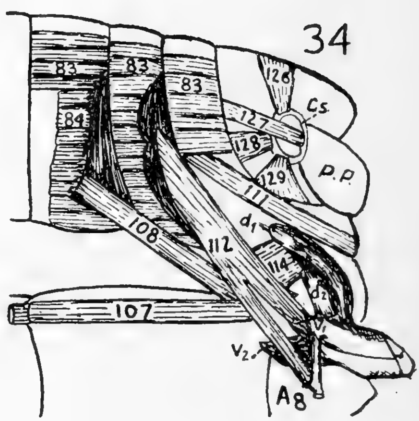

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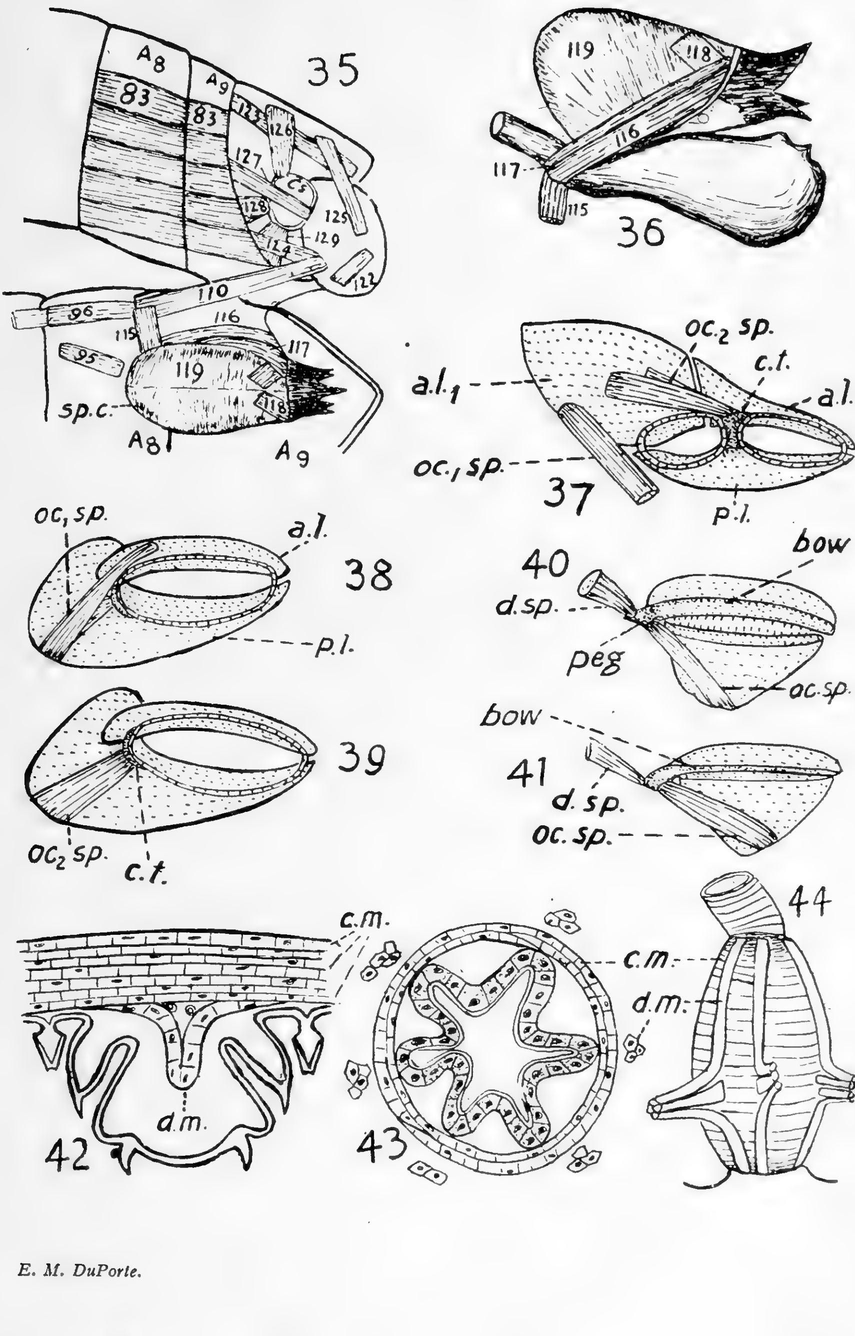
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oc.2 sp.
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38
oc.1 sp.
a.l.
p.l.
39
oc.2 sp.
c.t.
40
bow
d.sp.
peg
oc.sp.
41
bow
d.sp.
oc.sp.
42
c.m.
d.m.
43
44
c.m.
d.m.

E. M. DuPorte.

ANT GUESTS FROM FIJI AND THE BRITISH SOLOMON ISLANDS.

By William M. Mann,
U. S. Department of Agriculture, Bureau of Entomology.

The species hereafter described and noted were collected by the writer during 1915-1916, during an eighteen months' excursion to the South Seas as Sheldon Traveling Fellow of Harvard University.*

Orthoptera. (Family Gryllidæ).

Myrmecophila hebardi sp. nov.

Female: Length 2.75–3 mm.

Form elongate and rather more slender than usual in the genus Head brown, with a pair of yellow spots on the vertex. Thorax and first two abdominal segments lemon yellow; pronotum with a broadly interrupted fuscous band at middle; metanotum and first two abdominal segments with narrow, entire, transverse fuscous bands at base; remaining abdominal segments fuscous; the antennæ, tips of ovipositor and femora infuscated. Body and appendages with microscopic yellow pubescence; cerci with long and coarse hairs; thorax and abdomen above with scattered, squamiform hairs. Eyes flat, composed of 16–18 facets. Antennæ distinctly longer than the body and very slender. Pronotum slightly narrowed in front. Meso- and metanotum subequal in length and together slightly shorter than the pronotum. Cerci 9-jointed, rather stout, with joints 2–3–4 distinctly broader than long. Spines of posterior tibiæ arranged as follows: On the dorso-external margin at apical third, three spines, the basal of which is a little longer than the third, but only half as long as the second; the dorso-internal margin with six spines, the basal, the third and the sixth much shorter than the others; tips with a pair of short ventral spines. Metatarsus with one stout spine.

Host: *Plagiolepis longipes* Jerd.

Described from a series taken with the host ant in the following localities: Fiji Islands, Somo Somo, Taviuni (type locality), Lakeba, Munia and Kabara in the Lau Archipelago; Saiaro, Viti Levu; Vunisea, Kadavu. Santa Cruz Archipelago: Graciosa Bay. Solomon Islands: Pamua and Wainoni Bay, San Cristoval.

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* The figures were drawn by R. S. McEwen.

The squamiform hairs on the thorax are difficult to see and in many of the specimens have been rubbed off.

M. hebardi is close to *M. flavocincta* Wasmann, which lives with the same species of ant in India, but Rev. Wasmann has kindly compared the two and writes that in *hebardi* the joints of the cerci are much broader than in *flavocincta* and the latter species has yellow bands only on the pro-and mesonotum.

M. hebardi differs from the other species of Myrmecophila in confining itself to one host species. This probably accounts for the small amount of variation in size among the series before me. In a large collection of Myrmecophila the size of the crickets is seen to be in proportion to the size of the ant with which it lives. Small individuals are found in colonies of large ants, but in the collection before me, consisting of a series of nine species, it is very noticeable that the large-sized specimens of each species live with large host ants.

DIPTERA. (Family Syrphidæ).

Bardistopus papuanum gen. et sp. n.

(Fig. 1.)

(Near Microdon).

Female: Length 6.5 mm. Form very slender; color black with the sides of front, 2nd and 3rd antennal joints, apex of scutellum, metanotum, broad lateral stripes on first gastric segment and legs (except tarsi) reddish brown, tarsi yellowish white. Frons at vertex more than a third as broad as head, not narrowed toward antennæ, subquadrate in shape and barely longer than broad, coarsely and in parts confluently punctate. Ocelli flat, situated on a tubercle which is bordered in front and at sides by a deep groove. Occiput truncate. Face straight in profile, sides with coarse, short, black hairs and yellow pollinose pubescence. Antennæ very long; arista twice as long as basal joint; basal joint about six times as long as 2nd joint; terminal joint about seven times as long as the basal, very gradually thickened toward apex, which is rounded. Thorax coarsely and irregularly punctate and with abundant, semirecumbent, coarse, black hairs. Scutellum transverse, rounded above, unarmed, anterior posterior borders nearly straight. Metanotum strongly transverse; with a sub-circular, broad, shallow depression at middle, microscopically striolate and without hairs. Gaster four times as long as broad, rugulose and punctate, moderately densely covered with semirecumbent, silky hairs. First segment margined at sides and elevated in front; second segment transversely impressed in front, the impression deep near sides; third segment as long as the first and second together. Wings hyaline, veins brown. Halteres yellowish white.

Pawa; Ugi, British Solomon Islands.

Described from two females (one without developed wings) reared from pupæ found on a leaf in a nest of *Technomyrmex albipes* F. Smith.

The puparium is 7 mm. long and 4 mm. broad; is not as convex as those of Microdon and brownish in color and not reticulated.

I have considered *papuanum* as generically distinct from *Microdon* because of the structure of the antennæ.

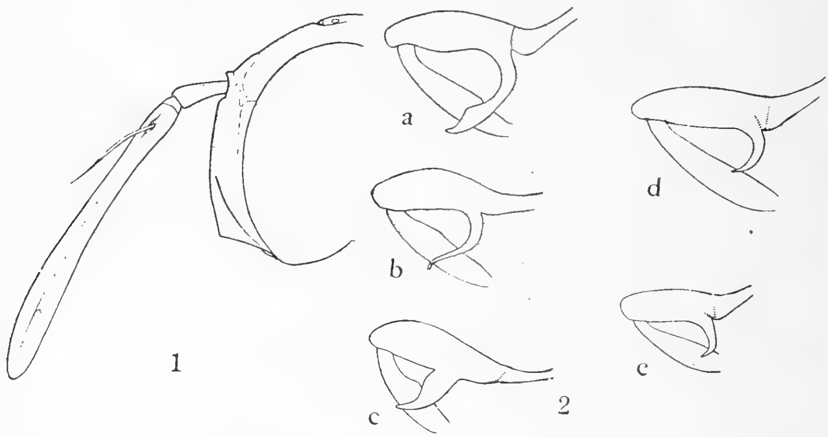

Fig. 1. *Bardistopus papuanum* gen. and sp. nov. Antenna and head from side.
Fig. 2. Middle femur, showing spines of *a*, *Fustiger vitiensis* sp. n.; *b*, *Fustiger raffrayi* sp. nov.; *c*, *Fustiger leverani* sp. nov.; *d*, *Fustiger wasmanni* sp. nov.; *e*, *Kaisia oceanica* sp. nov.

Coleoptera. (Family Pselaphidæ).
(Subfamily Clavigerinæ).

No species of this group have hitherto been recorded from the Melanesian region, but as they occur in nearly all parts of the world, it was not surprising to find some in a region as old zoologically as Fiji.

Five of the seven species that I found were taken at Nadarivatu, in the high mountains of Viti Levu, and four of them in company with the same host species, *Pheidole knowlesi* var. *extensus* Mann (mss.)*, a common species in the islands and one that nests beneath stones, a situation most favorable for the

* The ants named as host have been described in a paper on the ants of Fiji, now in the hands of the editor.

discovery of any inquilines in the nest. One was found with a Fijian species of Iridomyrmex, nesting in a Myrmecodia bulb and two with Prenolepis bengalensis Forel, an East Indian ant apparently well established in Fiji.

I am, with much doubt, placing five of my species in the genus Fustiger, though they are certainly exceedingly aberrant forms, and for two of the species I have considered it advisable to erect new genera.

Fustiger vitiensis sp. nov.

(Fig. 2, a; Fig. 3.)

Male: Length 1.25–1.50 mm.

Head about twice as broad as long, broadest in front, shallowly impressed transversely between eyes, smooth in front and with shallow, foveolate punctures behind. Antennæ longer than head, the third joint narrow basally, gradually enlarged for two-thirds its length and then suddenly thickened so that the apical third is sub-campanulate; basal two-thirds densely punctate and much darker in color than apical third, which is smooth and shining. Prothorax longer than broad and a little more than half as broad in front as behind; sides convex. Sides of eltyra feebly arcuate, posterior angles obliquely truncate, middle of border moderately concave. Abdomen with basal pit deep but not broad, lateral glandular swellings evenly rounded, only moderately excavated beneath; margins strong. Femora narrow basally, moderately swollen at apical two-thirds; the middle pair with thick spines which are broadened and subangulate in front of middle; the spines two-thirds as long as tibiæ.

Brownish red. Hairs yellow, coarse and straight, moderately abundant on head, thorax, abdomen and antennæ; short and sparse on legs. Fasiculæ well developed.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from a series taken at Nadarivatu, Viti, Levu, Fiji.

Fustiger raffrayi sp. nov.

(Fig. 2, b.)

Near *Fustiger vitiensis* from which it differs in the following characters:

The prothorax is proportionately longer and more than twice as broad behind as in front. The femoral spines are slender and bisinuate and not enlarged and angulate on inner border. The head is not strongly punctate on the posterior half. The size (length 1 mm.) is slightly smaller.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from several specimens taken at Vunisea, Kadavu, Fiji.

Fustiger cribratus sp. nov.
(Fig. 4.)

Male: Length 1.10 mm.

Dark brown, almost black. Head prothorax and elytra finely cribrately punctate and with microscopic recumbent hairs; abdomen, in addition to similar minute hairs with six long, fine and erect hairs.

Head less than twice as long as broad, as broad behind eyes as in front. Antennæ twice as long as head, slender, clavate and compressed apically. Prothorax a little longer than broad, sides rather strongly convex at middle, straight behind, dorsal surface with a strong circular impression at middle near base. Elytra together distinctly longer than broad, sides convex, apical corners rounded, sutural striæ strong. Abdomen narrow; pit short and deep with strongly sloping posterior surface, lateral anterior lobes elongate, well defined, excavated beneath, with fascicle at the tip composed of short hairs; posterior portion of abdomen convex, strongly margined at sides. Anterior femora strongly swollen at middle of inner edge. Spines of middle femora thick basally, then slender and acuminate apically, strongly curved.

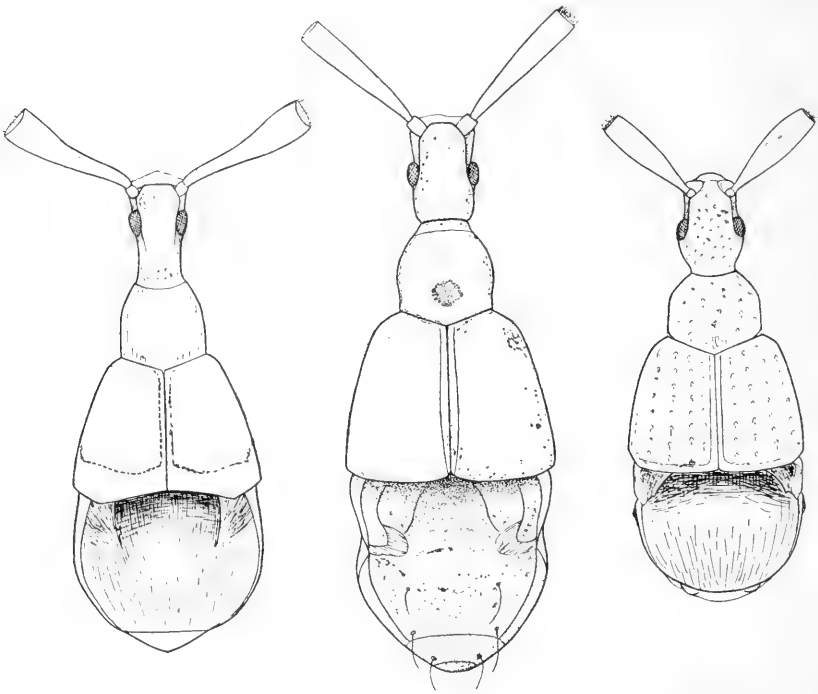

Fig. 3. *Fustiger vitiensis.* Fig. 4. *Fustiger cribratus.* Fig. 5. *Fustiger levuanus.*

Viti Levu: Nadarivatu.

Host: *Iridomyrmex sororis* Mann.

Described from two males taken with the host ant, in a Myrmecocdia bulb.

The elongate, slender antennæ, the regular punctation and the dark color are characteristic of *cribratus*.

Fustiger levuanus sp. nov.

(Fig. 2, c; Fig. 5.)

Male: Length 1.25 mm.

Reddish brown. Head, prothorax and elytra with rather stiff, suberect hairs; abdominal fasiculæ very small. Head less than twice as long as broad, widest behind eyes, coarsely, foveolately punctate. Antennæ about as long as head, second joint clavate, compressed at tips, uniformly punctate. Prothorax broader than long, broadest behind eyes, sides convex, surface foveolately punctate. Elytra a little broadest behind, sides convex, posterior corners rounded, surface with rather strong and regular foveolate punctures which become finer on apical third. Basal pit of abdomen not deep; barely one-third as long as abdomen; the surface posterior to the pit very strongly convex. Femora incrassate, the spines about half as long as tibiæ, stout basally and strongly curved. Disc of metasternum impressed, first gastric segment barely as long as second and third together.

Koro Vatu, Viti Levu, Fiji.

Host: *Prenolepis bengalensis*. Forel.

Nadarimanu gen. nov.

Note.—Near Fustiger, but differing in the structure of the abdomen, which is very strongly margined for its entire length and instead of a fasiculate inflation at the anterior end has a second, rounded margin which bears an elongate brush of hairs. Abdominal pit very broad, the posterior face flat and sloping and the non-excavated posterior part of the first segment reduced to a convex ridge. Type *alewa*.

Nadarimanu alewa sp. nov.

(Fig. 6*)

Female: Length 1.75 mm.

Reddish brown. Hairs rather coarse, curved, semirecumbent, abundant on head, body and appendages. Head, prothorax and elytra with strong, foveolate punctures which are largest and more shallow on the elytra. Abdomen very finely and sparsely punctate. Head about twice as long as broad, as broad at anterior border as behind eyes, not impressed above. Antennæ much longer than head, the third joint rather narrowly clavate and compressed. Prothorax a little longer than broad, narrowed in front, sides convex at anterior half, nearly straight behind; surface feebly depressed at base. Elytra together broader than

* The antennae are more sinuate than shown in the figure.

long, sides feebly convex, posterior angles sharp, border bisinuate; sutural striæ strong. First abdominal segment strongly margined for its entire length, without dilations, but with a second rounded margin which extends along the sides of the pit, this bearing along the sides a long, thin fasicle; pit very broad and shallow, extending four-fifths the length of the segment; its posterior three-fourths, very flat and sloping. First ventral segment longer than the following three together. Ventral surface of head and thorax with very coarse punctures, legs stout, femora enlarged and moderately compressed.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from one female taken on Mt. Victoria, Viti Levu, Fiji.

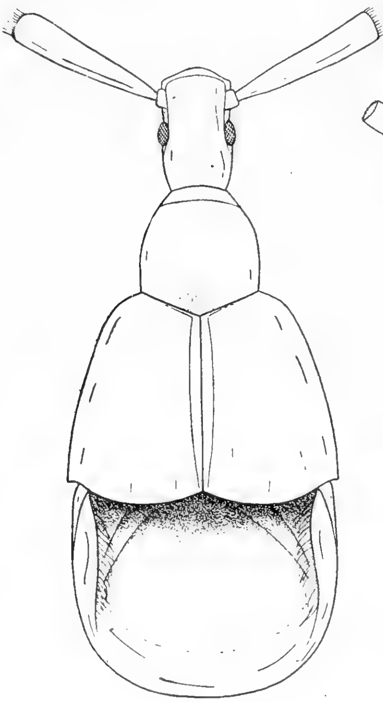

Fig. 6.
Nadarimanu alewa.

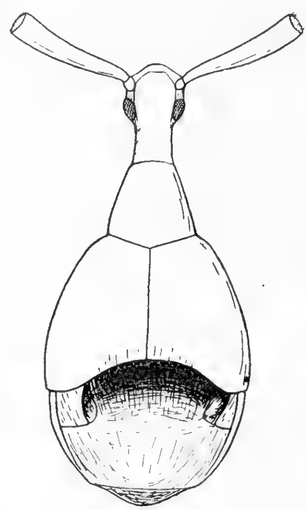

Fig. 7.
Fustiger wasmanni.

Fig. 8.
Kaisia oceanica.

Fustiger wasmanni sp. nov.

(Fig. 2, d; Fig. 7.)

Male: Length 1.25 mm.

Head constricted behind eyes into a neck, which is broadest basally, about two-thirds as broad and a little shorter than the anterior portion; the ventral surface strongly longitudinally impressed at middle with the

sides roundly margined. Antennæ distinctly longer than head. First joint smaller than the second, second joint transverse broader than basal portion of third. Third joint thick, markedly enlarged at apical third, circular and truncate at apex. Prothorax broad basally, narrowed in front, with nearly straight sides. Elytra together much broader than long, sides feebly arcuate, posterior corners narrowly rounded, the posterior margin truncate at sides and deeply concave at middle. Abdomen broad, the basal fovea extremely deep, grooved at bottom; dorsal surface posterior to pit strongly concave; lateral swellings large, deeply excavated and bearing extremely thin fasiculæ; side margins acute at anterior third, less so behind. Ventral surface of metathorax broadly rounded. First abdominal segment much longer than the following three segments together. Legs slender, the middle femora with short spines which are thick basally, narrowed apically, strongly curved and about one-third as long as tibiæ.

Yellow brown, shining, thorax and abdomen sparsely, regularly punctate. Head in front of eyes sparsely, rather coarsely punctate, posteriorly with strong, elongated and confluent foveolate punctures. Hairs yellow, coarse, strongly curved and moderately abundant on antennæ.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from a unique male taken at Nadarivatu, Viti Levu, Fiji.

The broad, oval form, the shape of the head, the thickly margined inferior sides of the neck and the exceedingly profound abdominal pit are very distinctive.

Kaisia gen. nov.

NOTE.—Kaisi (Fijian) = slave.

Form elongate. Head longer than broad. Eyes well developed. Antennæ four-jointed, the first joint very small, the third longer than the fourth which is truncate apically. Prothorax broad, strongly impressed at base. Elytra elongate. Abdomen small, with a deep, narrow pit in front and well developed lateral swellings and fasiculæ. Metasternum with a pair of broad foveæ which are separated by a longitudinal ridge of pubescence; apical margin with a pair of strong vertical spines. Type *oceanica*.

Kaisia oceanica sp. nov.

(Fig. 2, e; Fig. 8.)

Male: Length 1 mm.

Reddish brown. Hairs rather strong and sub-erect, regularly arranged and moderately abundant on head, pronotum elytra and abdomen. Fasiculæ of abdomen well developed, dense. Head less than twice as long as broad, as broad in front as behind, widest behind eyes, not impressed above; rugosely punctate. Eyes large and convex, sit-

uated at sides of head a little behind the middle. Antennæ a little longer than head, with three distinct joints; first joint small; second joint clavate, one and one-third times as long as the terminal from which it is separated by a strong constriction, punctate; third joint smooth and shining, nearly twice as broad as the second, broadest at apex, tip truncate. Prothorax slightly broader than long with a strong, elongate impression at middle of basal half, punctate similarly to head. Elytra together longer than broad, posterior corners broadly rounded, border shallowly concave at middle; coarsely shallowly and rather

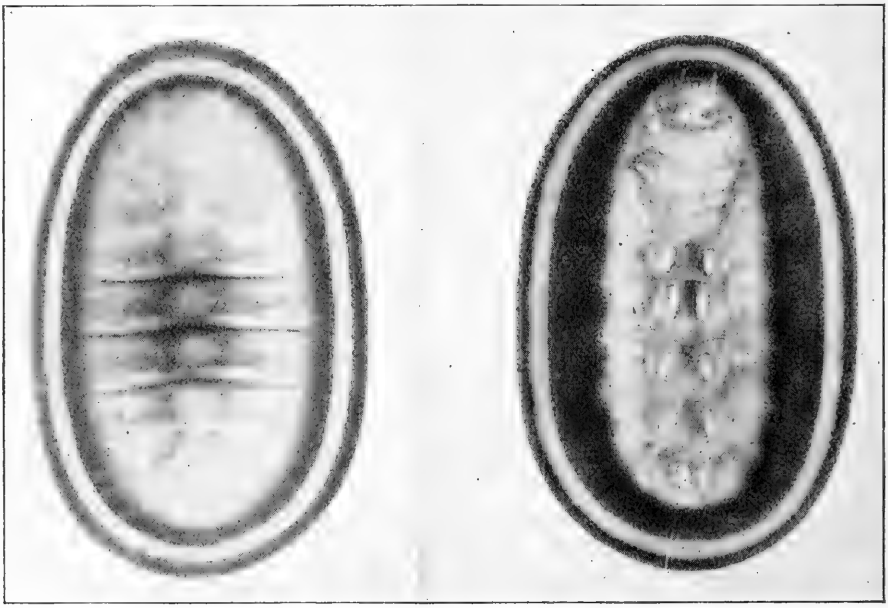

Fig. 9. *Liphyra brassolis* Westw. larva, dorsal and ventral views.

sparsely punctate. Abdomen distinctly narrower than elytra; first segment with strong lateral margin; anterior glandular processes moderately developed; pit small, occupying less than one-third of the surface, transverse, grooved at bottom. Femora of uniform thickness, armed basally with a rather thick spine, a little less than half as long as the femur, nearly straight at basal two-thirds, then bent at a rounded obtuse angle. Mesosternum apically with a pair of strong elongate, triangular spines in front of inner margin of posterior coxi. First ventral segment as long as the second and third together.

Host: *Prenolepis bengalensis* Forel.

Described from two specimens taken with a colony of the host ant beneath a stone on the Tai Levu Coast, Viti Levu, Fiji.

LEPIDOPTERA. (Family Lycaenidæ).

Liphyra brassolis Westw.
(Fig. 9.)

Several individuals of the singular, Dipterous-like larvæ of this species were found at Tulagi, British Solomon Islands, in the leaf and silk nests of *Oecophylla smaragdina* var. *subnitida* Emery. *L. brassolis* is found from Australia to India. It feeds on the larvæ of the host ant. The latter are unable to harm it, because of the heavy corneous larval skin, the edges of which fit closely to the leaf. At the time of pupation the larval skin becomes modified into a cocoon, within which the quiescent stage is passed; a condition analogous to that of the cyclorrhaph Diptera. When the adult emerges it is densely covered with scales which come off if the ants become aggressive and distracts their attention while the *Liphyra* escapes from the nest.

The larvæ much resemble those of Microdon, and glide along in a similar manner, though very much faster.

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* Dodd (Ent. 35, pp. 153–156, 1906) has given an interesting account of the habits, and Chapman (Ent. 35, pp. 225–228 and 252–255) of the development of specimens from Queensland.

THE PROCESS OF HATCHING IN CORYDALIS CORNUTA LINN.

Roger C. Smith, Ph. D.,
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A study of the manner of hatching of *Corydalis cornuta* was made to ascertain if there were an egg burster used. Dr. C. V. Riley (1876) stated in his observations on the life history of *Corydalis cornuta* Linn that "the egg burster* has the form of the common immature mushroom and is easily perceived on the end of the vacated shell." This note was repeated in his ninth annual Missouri Report, 1877 (p. 127). This is the only published account of hatching known to the writer, but in part has been quoted by many writers since its appearance. Through the kindness of Professor A. N. Caudell, of the National Museum, an abundance of preserved material was made available for study. Throughout the month of July of the current year, a large number of egg masses of *Corydalis cornuta* were found along a small stream near this laboratory on rocks in the stream and on several overhanging trees. Some were taken to the laboratory and observed for hatching.

There appears to be no doubt that Professor Riley misinterpreted a rather unusual shaped micropyle (Fig. 1) for an egg burster as suggested by Davis (1903). This micropyle, as is generally the case, is located at one end of the elliptical egg and in the Sialidæ, to which Corydalis belongs, has somewhat the shape of certain mushrooms in the button stage. It is attached to the exterior of the chorion and not to an inner structure as might be expected if it were an egg burster. It was not observed to serve any purpose whatsoever in hatching.

Professor Riley states further that egg bursters are generally if not always a part of the ambion (amnion, perhaps). This until relatively recently, perhaps to Heymon's work, 1906, appears to have been the prevailing opinion concerning egg bursters and we find in literature statements many times regarding the molting of the amnion at hatching.

* I am not aware that this special structure has been named. It is generally if not always, a part of the ambion, and common to many insects, though varying much in form. It may be known as the ruptor ovi. Dr. Hagen has called it the "egg burster," while erpetologists designate as "egg tooth," a structure having the same purpose.

Heymons (1906) states that the egg burster of the Pentatomidæ is a thickening and specialization of the embryonic cuticula. This cuticula is a very thin delicate structure undoubtedly rudimentary. It is molted at hatching and with it goes the egg burster. The writer has investigated the egg burster in the Chrysopidæ. It likewise is a specialized chitinous apparatus situated on the thin embryonic cuticula and the whole is shed at hatching. The molt was observed to withstand the action of heated caustic potash without injury and is undoubtedly chitinous. The writer concluded from a rather

Fig. 1.

Fig. 2.

Fig. 1. A micropyle of an egg of *Corydalis cornuta* highly magnified.

Fig. 2. Ventral aspect of an egg of *Corydalis cornuta* ready to hatch. Note the large mandibles, the two ocellar fields and the absence of an egg burster in the mid ventral cephalic region.

brief study of the embryology of the Chrysopidæ that the amnion was ruptured during the development of the embryo and was drawn into the mid-intestine with the last of the yolk to disintegrate or be absorbed. So the statement that they are generally if not always on the amnion can not be accepted in the light of later research. All egg bursters so far recorded are on a chitinous embryonic cuticula, which in most cases is shed at hatching as for example in the Chrysopidæ, Hemerobiidæ, Pentatomidæ, Trichoptera and the Psocidæ. Lepisma and the Pulicidæ are said to retain the egg bursters for a day or longer,

but no recent accounts have been given of this fact in either case. In *Corydalis cornuta* there is an embryonic molt, but a careful study of the same has not revealed any structure that might serve as an egg burster. Furthermore, the process of hatching gives no indication of the use of any such structure. On the other hand, hatching is effected by a means none the less interesting and perhaps unusual.

When egg masses of *Corydalis cornuta* are cut or scraped from their substratum, some eggs which are ready to hatch will often hatch in a short time, so that hatching may be readily observed. Frequently eggs that are ready to hatch, judging from external appearances, may hold over for several days. The hatching process proceeds rather slowly and varies in the length of time between stages. Eggs ready to hatch are smoky gray, often reddish or pinkish in the lower three-fourths and lighter gray anteriorly. On the venter of the egg, the amber colored bifid mandibles can be seen about one-third the distance from the anterior end of the egg (Fig. 2). At the sides can be plainly seen the two large black eye spots or ocellar fields, each with seven ocelli. The head of the embryo is therefore bent caudo-ventrad with the prothorax beneath the micropylar area.

Usually the first visible evidence of hatching is slight movements of the embryo. Under highest power binocular, air bubbles will be seen to be slowly going down the pharynx. As this continues the anterior region of the egg becomes perceptibly dilated. The chorion shrinks slightly as the air within is withdrawn until it becomes rather closely appressed to the embryo, suggesting premolting conditions. The contour of the embryo can now be plainly seen, the large head being very evident. The egg becomes asymetrical, due to the enlargement anteriorly and the shrinkage around the abdomen posteriorly. As the swallowing of air bubbles continues, the embryo exerts considerable additional pressure by pushing itself upward. The chorion over the anterior end of the egg becomes tightly stretched under the increasing internal pressure and finally gives way, providing the opening for the emergence of the larva. The rent is usually small at first and difficult to see, but soon increases to accommodate the large head of the embryo. In no case did the mandibles pierce the chorion to

start the rent. The embryo pushes itself feebly upward, the dorsum of the head first appearing. This upward shifting continues until the sixth or seventh abdominal segment is reached. During the emergence the swallowing of air bubbles increases in rate. The embryo normally stops at this stage of emergence for a varying period of time. It now casts off the embryonic molt in precisely the same way as hatching is effected. By continued swallowing of air the old cuticula is stretched further. Finally the swallowing of air bubbles is discontinued and the larva begins to work the abdomen forward as is done in many insects at molting. As the abdomen is brought forward within the old cuticula the thoracic region becomes greatly strained and finally tears over the prothorax. Immediately the broad, somewhat angular prothorax appears. The setae straighten up as the smooth glassy coat slips back. The thorax is slowly pushed through the rent. The molt is held back by the mouth parts causing the head to be turned ventrad so that the larva forms a loop over the egg.

The heavy chitinous mandibles and abdominal hooks are not shed as might be expected. This thin embryonic cuticula resembles more a tight fitting sack than a true molt. It is probably not attached (or is very loosely attached) to the inside of the chorion at some place as in the Chrysopidæ and Pentatomidæ for many embryos in confinement tumble from the egg and fail to cast this embryonic molt. All such larvæ died. The legs before shedding this molt are useless and the lateral abdominal filaments are bound close to the body. After the molt the larvæ are very active and the filaments expand to their normal position. This molt lies normally in the rent of the egg shell.

The writer concludes that hatching and the first molt are effected by the swallowing of air bubbles combined with the upward pushing of the embryo. The rent in the chorion is at the anterior end generally at one side of the micropyle. If the empty chorion be mounted and examined microscopically it will be seen that the rent is generally ragged and has the appearance of being torn by internal pressure. Sometimes the entire upper end of the egg is torn off as if it were a cap.

The phenomenon of swallowing air bubbles to effect hatching and molting has been recorded several times in literature.

Kunckel (1890) pointed out that nymphs of the Acridelideidæ accumulated air in their crops, causing the "ampoule cervicale" of each to become dilated which in turn raised the lids of their earthen cases. He states further that the swallowing of air bubbles is the chief means of molting. Peyerimhoff (1901) states that the embryos of the Psocids regularly swallow air bubbles to increase their size and enable them to exert the necessary pressure at hatching. This writer also gives a brief summary to date of the literature on the point. Heymons (1906) has noted the increase in size of Pentatomid nymphs at hatching by taking in air and adds that Foriculidæ do likewise at molting and hatching. The phenomenon is perhaps more common than a bibliography indicates.

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SOME OBSERVATIONS ON THE GENITALIA OF LACHNOSTERNA.

By W. P. Hayes and J. W. McColloch,
Kansas State Agricultural Experiment Station.*

In making a study of the *Lachnosterna* of Kansas, the writers have examined approximately 50,000 specimens for specific determination. The works of Horn (1887) and Smith (1889) were used in most of this work. Smith's paper was especially helpful in making specific determinations, because of the large series of figures illustrating the genital characters which are now generally recognized as the best means of separating the different species of this genus. Several species of *Lachnosterna* occur in Kansas, however, that are not figured in this paper, and in order to facilitate the identification of them, illustrations of the genitalia were prepared.†

Since many others are working with this group, it seemed advisable to present these figures at this time in the nature of a supplement to Smith's paper. It is not the purpose of the writers to go into detail concerning the identification of the various species, since Glasgow (1916) states that he is making a thorough systematic study of the genus. Several discrepancies in Smith's figures of *L. corrosa*, *L. crenulata*, and *L. rubiginosa* are also discussed. In addition, a brief discussion is made of specific and sexual determination in the pupal stage.

DISCUSSION OF GENITALIA.

Lachnosterna prætermissa Horn (Plate I, Fig. 7).

This species is occasionally taken in Kansas, seven females and four males having been collected in the vicinity of Manhattan. The figures of the male genitalia are presented by Smith. The female genitalia approach that of *L. implicata.* Superior plates are wanting and the pubic process is characterized by being heart-shaped, deeply cleft, slightly divaricate and clothed with a sparse covering of short, erect hairs.

*Contribution from the Entomological Laboratory, Kansas State Agricultural College, No. 49. This paper embodies the results of some of the investigations undertaken by the authors in the prosecution of project No. 100 of the Kansas Agricultural Experiment Station.

†The writers wish to express their thanks to Mr. J. J. Davis for the determination of the specimens from which the Figures are prepared.

Lachnosterna longitarsa Say (Plate I, Fig. 4).

A good series of this species was taken in flight at Manhattan during the summer of 1917. Illustrations of the female genitalia are lacking in Smith's paper. In the female the inferior plates are subquadrate and the superior plates are triangular. The pubic process is reduced to a small protuberance between the superior plates.

Lachnosterna hirtiventris Horn (Plate I, Fig. 3).

A number of specimens of this species are in the writer's collection from southern Kansas. Only the male genitalia are figured in Smith's work. The superior plates in the female are lightly corrugated and the pubic process is deeply cleft and slightly divaricate.

Lachnosterna calceata Lec. (Plate I, Fig. 1).

L. calceata is a common species in the southern half of Kansas. Smith does not figure either sex of this species. The genitalia of the male are symmetrical and approach the *L. crassissima* type. In the female the superior plates are modified into the pubic process which is elongate, bifid and tapering to a point.

Lachnosterna glabricula Lec. (Plate I, Fig. 6).

The males of this species are common in the vicinity of Manhattan during July and August. Three females were found around the roots of sumach (*Rhus* sp.) in 1917, in an area from which the males were emerging in large numbers. The pubic process in the female is wanting. The superior plates are fused, deeply emarginate and fringed on the posterior end with moderately long hairs.

Lachnosterna tristis Fab. (Plate I, Fig. 5).

This species is rare in some sections of Kansas. Smith presents figures of the male genitalia only. The female genitalia are rather simple as in *L. heterodoxa*, consisting of an unique development of the inferior plates. In the case of *L. tristis*, the grooves formed by a fold on the ventral side of the inferior plates are longer and apparently deeper than in *L. heterodoxa*. The posterior ends of these plates are fringed with slightly recumbent hairs.

Lachnosterna corrosa Lec. (Plate I, Fig. 2).

This species is frequently encountered in Kansas. According to Glasgow (1916) *L. affinis* is synonymous with *L. corrosa*. An examination of the specimens at hand show a variation in the genitalia of both sexes from the illustrations presented by Smith for either *L. corrosa* or *L. affinis*. In general they more nearly approach the *L. affinis* type. In the males the claspers are seen to be unsymmetrical. The female genitalia are rather characteristic. The inferior plates are large and are notched to receive the greatly reduced and modified superior plates. The pubic process is prolonged, divaricated and sparsely clothed with hairs.

Lachnosterna crenulata Froel., and **Lachnosterna rubiginosa** Lec. (Plate I, Figs. 8 and 9).

These two species occur in Kansas, the latter being one of the most common species in the vicinity of Manhattan. Both species are readily separated by the character of the lateral margin of the thorax which is strongly crenate in *L. crenulata* and but feebly so in *L. rubiginosa*. The genital organs of the females of both species are rather simple and very similar. The superior plates are fused along the median line and are deeply emarginate. A small, tooth-like projection occurs at the base of this emargination in *L. rubiginosa*. In Smith's figures, this tooth-like process is shown in *L. crenulata*. The superior plates are fringed with hairs of moderate length, the hairs being more numerous in *L. crenulata*.

SPECIFIC DETERMINATION IN THE PUPA.

Since it is often desirable to be able to identify the species of *Lachnosterna* pupæ, the following observations are offered as an aid of considerable value in the case of pupæ that have reached a somewhat advanced stage of development. As is well known, the grubs are not specifically separable and it is usually necessary to rear them to adults in order to make determinations. Often they reach the pupal stage and die. Fortunately, the genitalia develop at a comparatively early stage and so lie within the body of the pupa that they become visible through the pupal skin after the adult coloration begins to develop.

The sexes are easily distinguished as soon as pupation occurs. The lamellate club of the antennæ in most species is larger in the male than the female, and thus affords one means of determination. However, this offers some difficulty in species where size differences are not pronounced. In such instances, a second and more reliable method can be adopted. On the ventral surface of the female pupa, immediately cephalad to the anal slit, are two elevated subquadrate structures (Plate II, Fig. 10 r) which are characteristic of female pupæ. In the male (Plate II, Fig. 11 r) the same structures are present, but lying somewhat between and caudad to them is a third rounded and somewhat conical elevation (Plate II, Fig. 11 t) which is characteristic of all male pupæ examined. The sex of *L. lanceolata* is also determinable by the size and shape of the male and female pupæ.

The anal aperture of the adult beetle developing within the pupa is so opened as to allow the genitalia of both the males and females to protrude enough to be discernable under the pupal skin. They can be seen under and in the near vicinity of the structures described above, which are used in sex determination. All that is needed is a familiarity with the genitalia of the different species. Figure 11-N shows a ventral view of the posterior region of a male pupa of *L. crassissima*, and Figure 11-O is a lateral view of the same. In both views the male genital organ can be plainly seen in the region marked "x." Figure 10-L is a ventral view of the female of the same species, and Figure 10-M is a lateral view. In the female the genital organ may be found somewhat anterior to the two lobular subquadrate structures, as shown in Plate II, Fig. 10-p, or they may lie directly beneath them.

As stated, the genitalia are only visible after the body begins to assume its darkened coloration. Records kept during the past summer show this time of coloring to vary, but it is of sufficient duration in a large number of cases to enable determination to be made over the latter half of the pupal period. The pupal period of *L. crassissima* was found to vary from 16 to 58 days, with an average, for 178 individuals observed, of 30.5 days. The following table shows, in a few individuals observed, the time elapsing between pupation and the date when specific determination was possible, as well as the time during which the genitalia were visible.

TABLE I.

PERIOD OF PUPAL DETERMINATION.

Species	Number of days from pupation to determination	Number of days from determination to maturity	Length of pupal stage days	Sex
L. crassissima......	14	15	29	♀
	13	16	29	♀
	7	22	29	♂
	15	13	28	♀
	16	12	28	♂
	15	15	30	♂
	14	16	30	♀
	15	15	30	♂
	12	18	30	♂
	12	18	30	♂
	17	11	28	♂
	5	25	30	♂
L. rubiginosa.......	15	14	29	♂
	13	18	31	♂
	10	18	28	♂
	26	4	30	♀
	24	4	28	♀
	22	6	28	♀
L. rugosa...........	11	19	30	♂
	17	13	30	♂

Two striking cases are to be noted in the case of *L. crassissima* when the pupal specific identification was made 22 and 25 days before maturity in pupæ, whose complete pupal stages were 29 and 30 days, respectively. The genital plates of the females of *L. rubiginosa* are not very prominent even in the adults which may account for the shorter period allowed for the determination in the three females noted in the table. Other species in which similar determinations were made include *L. implicata*, *L. crenulata*, *L. prætermissa*, *L. bipartita*, *L. corrosa*, and *L. lanceolata*.

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EXPLANATION OF PLATES.

Plate VIII.

Fig. 1. Genitalia of *L. calceata*, male and female.
Fig. 2. Genitalia of *L. corrosa*, male and female.
Fig. 3. Genitalia of *L. hirtiventris*, female.
Fig. 4. Genitalia of *L. longitarsa*, female.
Fig. 5. Genitalia of *L. tristis*, female.
Fig. 6. Genitalia of *L. glabricula*, female.
Fig. 7. Genitalia of *L. prætermissa*, female.
Fig. 8. Genitalia of *L. crenulata*, female.
Fig. 9. Genitalia of *L. rubiginosa*, female.

Plate IX.

Fig. 10. Caudal segments of pupa of *L. crassissima*, female.
Fig. 11. Caudal segments of pupa of *L. crassissima*, male.

ABBREVIATIONS USED IN FIGURES.

A. Female genitalia, ventral view.
B. Female genitalia, lateral view.
C. Female genitalia, dorsal view.
D. Male genitalia, dorsal view.
E. Male genitalia, left clasper, lateral view.
F. Male genitalia, caudal view.
G. Male genitalia, right clasper, lateral view.
H. Male genitalia, ventral view.
L. Caudal segments of pupa of ♀ *L. crassissima*, ventral view.
M. Caudal segments of pupa of ♀ *L. crassissima*, lateral view.
N. Caudal segments of pupa of ♂ *L. crassissima*, ventral view.
O. Caudal segments of pupa of ♂ *L. crassissima*, lateral view.

i. Inferior plates.
p. Pubic process.
r. Subquadrate structures.
s. Superior plates.
t. Conical protuberences.
x. Male genitalia.

Hayes and McColloch.

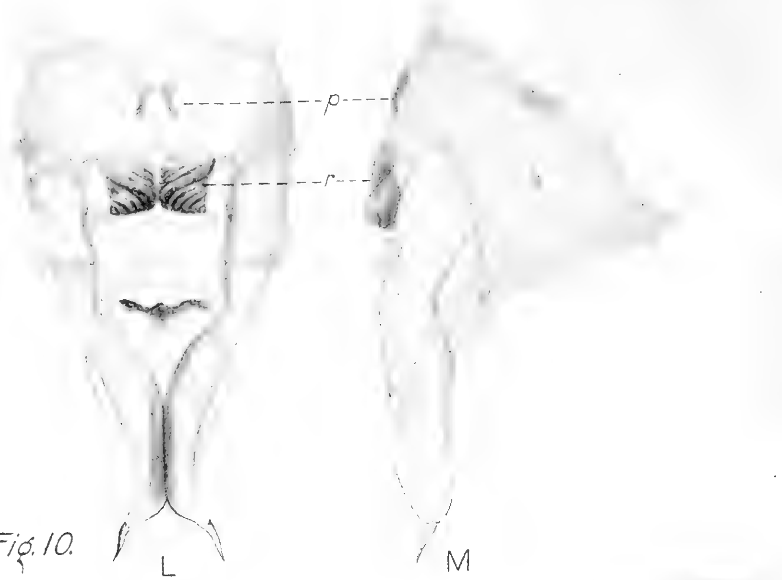

Fig. 10.

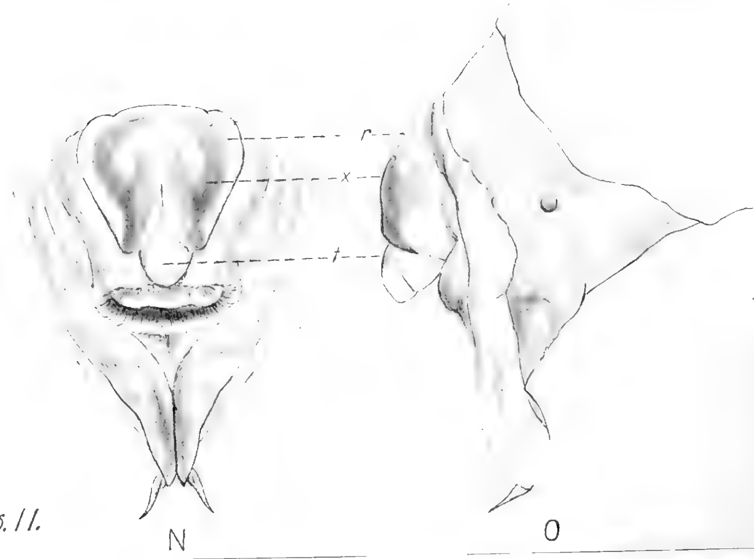

Fig. 11.

Hayes and McColloch

A REVIEW OF THE SPECIES OF THE GENUS GYPONA OCCURRING IN NORTH AMERICA NORTH OF MEXICO (HOMOPTERA).

By E. D. Ball.

Germar founded the genus *Gypona* in 1821 for *Cercopis glauca* Fab. and its allies. Since that time 198 species have been described or referred to this group all from North and South America. Of this number over 100 have been named from North America.

The genus as a whole is composed of large broad and striking species of wide distribution but of comparative rarity in collections partly on account of their agility in avoiding capture and partly on account of restricted food habits. Most of the species are widely variable in size and structure and still more unstable in color. In several groups the males are usually strikingly and variably ornamented while the females are plain.

The majority of these so-called species have been described from single examples or single sexes and little attention has been given to previous work. Spangberg in 1878 in his Species Gyponæ lists 96 species, 55 of which were new, without listing a single synonym, but omitting 12 old species which he did not recognize. His keys and descriptions fail to recognize the difference between specific, varietal and only sexual characters. In later papers he added 41 more new species still without recognizing a single duplication or error in determination, indicating an adherence to the Walker cult of quantity rather than quality.

Gibson in 1919 published a brief synopsis of the North American forms in which he recognized the extreme variability in the reticulate veined group and brought most of the synonomy of *octolineata* Say together. His material in other groups was not as complete and he failed entirely to recognize the difference in color in sexes and the extreme variability in other species with the result that here the confusion was only increased. He placed much reliance on the presence or absence of black marks on the pronotum and hinges and used it in his keys with disastrous results. This character is widely and commonly variable in a number of species such as *rugosa*, *melanota* and *scarlatina*, and more rarely variable in many others.

The writer some years ago brought together all the then available material from the region of the United States, intending to publish a synopsis of this group following the same lines as his work on the *Tettigonidæ*. When the material was assembled it was painfully evident that there had been little or no biological work done on this group and that there were no carefully bred series on which to base a study of the limits of variation. Without such a basis it was evidently impossible to determine the specific limits in this chaos of names so the material was returned and the matter dropped except for the collection of biologic material at every opportunity.

The appearance of Gibson's synopsis with its many obvious errors of reference and synonomy, which if not speedily corrected will cause endless confusion, caused the writer to again look over the situation with reference to available material. A trip to the East, in which a half dozen collections including the National Museum were studied, showed that for at least three of the worst confused species that sufficient material was available so that these species could be properly characterized, the variations in the color and size of sexes correctly pointed out and a large part of the present confusion cleared up.

When it is remembered that the whole 198 names apply to a rather small number of species and that a very large part of the types of these so-called species are in European museums and the only possibility of determining their characters is through meager descriptions it will at once be evident that even though the species be correctly defined it may not be possible in every case to determine the oldest name that will finally apply to a given species. Some further changes in synonomy may therefore be expected when type studies are made. Fortunately or unfortunately, however, we shall have an abundance of names that certainly apply to a considerable number of the species.

Key to the Subgenera of the Genus Gypona.

A. Vertex and front meeting in an acute angle, the margin more or less produced and foliaceous.
  B. Venation more or less reticulate........................ *Gyponana* nov.
  BB. Venation not reticulate; 5 apical and 3 anteapical cells.
    C. Elytra without dots or lines in the areoles, front broad, our species green or black.......................... *Gypona* Germ.
    CC. Elytra with dots or lines in the areoles, the front narrow, species cinereous or brown, never green.................. *Prairiana* nov.
AA. Vertex and front broadly rounding or with the margin thick and only slightly produced.. *Ponana* nov.

Subgenus **Gyponana** Nov.

Resembling *Gypona* in size and form, but with the venation of the elytra broken up into numerous irregular reticulations. Vertex broad, flat, meeting the front in an acute angle the margin foliaceous. Pronotum broad, transverse, striated, elytra elongate, narrowing apically, the appendix very narrow, entire apical area at least broken up into irregular reticulations.

Type of the subgenus *Gyponana octolineata* Say.

The more typical members of this genus are large, broad, green species, with more or less of scarlet or yellow striping. The amount of reticulation is very variable in some species, while quite constant in others.

Key to Species of Subgenus Gyponana.

a. Costal margin of elytra with fine black dots; whole insect more or less peppered with scarlet and black points....................1. *dracontea*, Gib.

aa. Costal margin without black dots, whole insect green, often with red or yellow lines.

b. Elytra subhyaline smooth, vertex sloping, segment rounding, black spots wanting......................................2. *octolineata*, Say

bb. Elytra nearly opaque, strongly rugose, shining, vertex flat, female segment rectangularly emarginate, black spots on pronotum and hinge usually present...3. *rugosa* Spgb.

1. **Gypona (Gyponana) dracontea** Gib.

This small gray-brown species slightly superficially resembles a gray form of *Xerophlœa*. It is by far the smallest of the group in our fauna and is only known from Arizona.

2. **Gypona (Gyponana) octolineata** Say.

This is the commonest and most widespread species in our fauna occurring from Canada to Florida, and from Nova Scotia to California. It varies greatly in size, color and in amount of reticulation and may be divided into varieties as enumerated below. Its reticulate elytra will separate it from all other green species but *rugosa*, from which the almost straight segment and the striping will usually distinguish it. It is apparently a very general feeder on different shrubs and trees.

Var. **octolineata** Say.

Green, washed with scarlet with definite scarlet stripes and more or less scarlet on the heavy reticulations.

Say described this species from Missouri and fixed the name *octolineata* on this variety by describing the markings as scarlet

and extending on to the reticulations, while he made the form with yellow stripes a variety.

This variety probably occurs throughout the range of the species but is most abundant in the Atlantic coast region.

Var. **striata** Burm.

Gypona cana Burm.; *Gypona flavilineata* Fh.; *Gypona quebecensis* Prov.; *Gypona scrupulosa* Spgb.; *Gypona olivacea* Spgb.; *Gypona geminata* Osb.

Green with six more or less definite yellow stripes on vertex and pronotum. Reticulations very variable.

This form is the most common one throughout the wide range of the species. It was described from Pennsylvania. Burmeister was evidently not aware of Say's descriptions of *octolineata* at the time. *Gypona cana* Burmesiter described for Carolina probably represents the heavily reticulate type. The peculiar genital structure described by Burmesiter in connection with *cana* has not been found in any member of the genus and was probably based upon a mutilated specimen.

Var. **pruinosa** Spangb.

Examples of a pale, slightly reticulated and usually markedly pruinose variety occurring from Georgia to Texas are placed here.

3. **Gypona (Gyponana) rugosa** Spangb.

Gypona ramosa Kirk; *Gypona delicata* Fowl.

Yellowish green, elytra heavily reticulate, whole surface coarsely rugose shining. Female segment deeply rectangularly notched. Some examples show definite black spots on pronotum behind the eyes and definite pale lines. Others vary all the way from this to entirely wanting.

This very active species is found both as larvæ and adult on the burr and white oak from New York, Wisconsin and southern Colorado, south to Florida and Mexico, and west to Arizona. Gibson separates *ramosa* Kirk, on the black spots, but all gradations in this character are common; *delicata* of Fowler, is evidently an immature example of this species.

Subgenus **Gypona** Burm.

Very large broad leaf hoppers with long, flat vertices sharply angled with the front, the margin thin, and foliaceous. Venation constant, five apical and three anteapical cells. Burmeister

placed *Cercopis glauca* Fab. as his first species and type of his genus. This is a South American species resembling *melanota* but much larger.

Key to the Species of Gypona Burm.

A. Head broad, vertex rounding, species golden, green or black.
  B. Broad and stout (*verticalis* excepted), with more or less of black in the males, not confined to the appendix and with black dots on pronotum.
    C. Vertex short, ocelli closer to eyes than to each other. Dull green, usually with more or less black on median dorsal line. 1. *dorsalis* Spgb.
    CC. Vertex longer, ocelli equidistant, males frequently shining black.
      D. Stout, elytra short, female dull green, male green or shiny black, elytra often hyaline.....2. *melanota* Spgb.
      DD. Slender, elytra long, parallel, female golden, male gold and smoky to shining black.........3. *verticalis* Stal.
  BB. Species smaller, golden, green or testaceous, without markings except sometimes a smoky line on appendix...............4. *unicolor* Stal.
AA. Head narrow, vertex angulate, ocelli nearer each other than eye, species pale, no spots or markings...........................5. *angulata* Spgb.

1. **Gypona dorsalis** Spg.

Gypona dictitoria Gib.

Big broad, green, unmarked or with variable irregular dark spots and marks mostly confined to the median line, often a pair of round black spots just behind the ocelli, irregular angular markings on scutellum and numerous smaller ones along scutellar and sutural margins of elytra. The dorsum of the abdomen may be dark at the base.

This species occasionally has a few reticulations near the tip of the elytra, but the stout body, shorter vertex and dark markings will separate it from the species of *Gyponana*, while the broadly produced median lobe between two acute lateral ones of the female segment will separate it from all others. Spangberg described *dorsalis* from Mexico, while Gibson described it again from Arizona examples. The writer has examples from New Mexico and Arizona. It is probably confined to the Southwest. Gibson places *dorsalis* as a synonym of *angulata* with a question. They are, however, very distinct as originally described, *dorsalis* being twice as wide as *angulata*.

2. **Gypona melanota** Spangb.

Gypona bipunctulata Woodw. (not Gibs.); *Gypona nigra* Woodw.; *Gypona bimaculata* Gib. (not Spangb.); *Gypona unicolor* Gib. (not Stal).

This is the broadest and shortest of our leafhoppers. Female pale green, unmarked except that they sometimes have a pair

of round black spots on the pronotum back of the eyes and another pair on the hinges. Males varying from entirely shining black to partly black, with milky subhyaline elytra, the black abdominal markings showing through, or in extreme cases entirely pale green, like the females. The female segment is nearly truncate and the male plates are broad and short.

This species is fairly common from Massachusetts to New York and Georgia, west to Minnesota, Iowa and Kansas and almost to the Rocky Mountains in Colorado. It is never found in trees or in shrub-covered areas. It is so heavy bodied that it does not fly readily. The writer has frequently found both sexes, together with the green larvæ in areas of prairie grasses. As there is no other species in this region closely related to this, there can be no question about the relation of the five color varieties of males. Osborn and Ball pointed this out in '97, but both Van Duzee and Gibson have ignored it.

Spangberg described the species from males from New Jersey and Georgia. Either he did not have the female or else confused it with some other species. Woodworth, ignorant of Spangberg's work, described each sex separately. The writer has examined the examples in the Illinois collection and found the above synonym to be correct. Gibson, not recognizing the relation between the sexes, identified the females without black spots as *unicolor*, those with spots as *bimaculata* Spgb. and the dark males as *melanota*. The true *bimaculata* Spgb is, however, evidently the female of the next species and not of this one, and while the real status of *unicolor* is somewhat doubtful, it cannot apply to this species.

3. **Gypona verticalis** Stal.

Gypona mexicana Spangb.; *Gypona bimaculata* Spangb.; *Gypona unicolor* var. *nigrodorsalis* Spangb.; *Gypona nixabunda* Gibs.; *Gypona germari* Stal.

Smaller and much narrower than *melanota*, females resembling *rugosa*. Golden green or yellowish. The females and light males agree in having round black spots on pronotum and black marks on hinge. The males vary from golden green to smoky or shining black, with about five varieties as in *melanota*.

This Rocky Mountain species may be readily separated from its eastern relative by the much narrower and nearly parallel margined appearance, by the golden shade on all but

the darkest males, as well as by its structural characters. The writer has found this species feeding abundantly both as larvæ and adult on the snowberry *Symphoricarpos* sp., in the mountain regions of Colorado. Examples are at hand from New Mexico and Arizona and various places in Mexico south to Vera Cruz.

This and the preceding species need not be confused, as their ranges and food plants are apparently quite distinct. Both species usually carry the black spots on pronotum and hinge but only *verticalis* shows traces of the yellow stripes and that rarely. There has been much confusion and synonomy in this species due to its wide variability. Stal described it twice, both times from males. Spangberg described each sex as a distinct species. Fowler in the Biologia described them separately while Gibson added to the confusion by wrongly identifying *bimaculata* and re-describing the green female as *nixabunda*, listing only the dark males as *verticalis*.

Gypona germari Stal is probably the light form of this species. As noted below, Fowler, however, evidently figures and described *angulata* under this name in the Biologia, although the two species belong to widely different groups.

4. **Gypona unicolor** Stal.

Gypona unicolor Stal (not Gibs).

The species here listed as *unicolor* is small, compact, pale green without markings except for a slightly smoky shade on the appendix. It is smaller and less parallel in form than *verticalis*, from which it is also distinct by the truncate segment and wide ocelli. The writer took this species in considerable numbers from the clumps of dwarf oaks growing on the mesas at Dolores in Southwestern Colorado and has specimens from Williams, Arizona and Mexico. As noted above Gibson's specimens labeled *unicolor* were all green forms of *melanota* without the black spots. These could not be Stal's species by either description or known range. Stal described *unicolor* as between *verticalis* and *germari* which are probably only color variations of the same species and when the types are critically studied, *unicolor* of Stal may prove to be only the green form of *verticalis*. The present species, however, appears to be distinct in structure, food plant and habit and answers the description in every way. Fowler notes that there is a specimen from Colorado in the Vienna Museum.

5. **Gypona angulata** Spangb.

Gypona tenella Spgb.; *Gypona germari* Fowl. (not Stal).

The angled vertex, together with the elongate form render this a strikingly distinct species. Superficially it resembles the paler forms of *striata* but lacks the reticulations.

The writer has taken it quite freely on the loco weed (*Oxytropis lambertii*) in the foothills of the Rockies in Colorado and has examples from British Columbia to Vera Cruz, Mexico. This species was described from a male from Texas. Later Spangberg described *tenella* from both sexes from Georgia. No material has been seen that indicates that there are two species in our fauna, and there is nothing in the original description that would separate them.

Gibson places *dorsalis* as a questionable synonym of this species although it was described as twice as broad as *angulata* with an entirely different head.

Subgenus **Prairiana** nov.

Resembling *Gypona* but with a much narrower and longer front and small, widely separated eyes. Vertex flat, elongate nearly equalling the pronotum, angulate, meeting front in a thin, foliaceous margin, ocelli on the disc distinctly in front of eyes. Front narrow and parallel margined in typical examples, often twice longer than wide. Antennal sockets close to front. Species pale gray to brown, entirely peppered with fine fuscous points which margin the nervures of the elytra. Darker examples may have linear markings in the areoles.

Type of the subgenus *Prairiana cinerea* Uhl.

The obscure and uniform coloration of this group is striking and probably an adaptation to the color of the dead grass blades around the margins of the clumps under which they live.

Key to Subgenus Prairiana.

A. Ocelli farther from eyes than from each other, elytral areoles with dark margins, central markings faint or wanting.

B. Front narrow, almost parallel, twice as long as its antennal width, vertex long, convex, irregular. Markings in areoles obscure or wanting, nervures margined with black punctures....... 1. *cinerea* Uhl.

BB. Front wider, less than twice as long as its width. Vertex shorter. Marking in areoles definite, especially in the male...2. *miliaris* Stal.

AA. Ocelli farther from each other than eyes. Antennal sockets touching eyes. Elytral areoles heavily marked with irregular brown areas and faintly margined..3. *fraudulenta* Spgb.

Gypona (Prairiana) cinerea Uhl.

Uhler described this species from a rather small stout example from Manitou, Colorado. It, however, occurs in a number of quite distinct varieties. They all agree in possessing the long, flat, angulate vertex, the very narrow parallel margined front and the cinereous color with the fine dark punctures. Beyond this they are remarkably distinct and at first would be regarded as extremely well marked species in both size and form. It is possible that the extreme forms *ponderosa* and *subta* may be distinct but in so variable a group it is best to await good life history studies before erecting distinct species when varietal descriptions will serve every purpose and avoid confusion. Gibson refers *cinerea* to the extreme Southwest, but specimens have been examined from Montana, Colorado, Dakota, Kansas, Iowa and Illinois. It is probable that most if not all of the eastern references should be transferred to the next species. This species has never been taken in the mountains and is probably strictly limited to the "short grass" regions.

Gypona (Prairiana) cinerea var. **ponderosa** n. var.

Resembling typical *cinerea* but larger and much broader and heavier. The vertex is so broadened that the apex is broadly rounding rather than angulate. The elytra only equal the abdomen as in typical *cinerea*. The coloration is that of *miliaris* females with the black points back of ocelli large and distinct, the pronotal pits back of these deep and fuscous marked. There are slight fuscous markings in many of the elytral cells. Length of females, 11 mm.; width, 4 mm.

Described from a single female taken by the writer in a meadow on the plains east of Greeley, Colorado.

Gypona (Prairiana) cinerea var. **kansana** n. var.

Resembling *cinerea* but with long narrow parallel elytra and definitely angled vertex. Pale cinereous, finely punctured, the males inclined to be smoky. Length, 9 mm.; width, 3 mm. Described from four examples from Onaga, Kansas, collected by Crevecœur. This is apparently the most common variety of the species. The writer has collected it sweeping over prairie grass in Colorado and Iowa and Crevecœur took it abundantly

in Kansas. *Gypona spreta* Fowl seems to be another variety of *cinerea* with a still longer and more sharply angled vertex than *kansana*.

Gypona (Prairiana) cinerea var. **cinerea** Uhl.

Stout gray or smoky cinereous forms with the elytra slightly longer than the body in the females, distinctly folded and narrowing posteriorly giving a stout, short form. The males have slightly longer elytra but are much shorter and stouter bodied than var. *kansana*. This variety has been taken from Colorado and Montana, east to Iowa. Most examples have been swept from upland prairie grasses.

Gypona (Prairiana) cinerea var. **subta** n. var.

Resembling variety *cinerea*, but much smaller and shorter with short rounding elytra exposing the apical segment of the abdomen. These appear to be true brachypterus forms with the appendix wanting and the apical cells rudimentary, but the under wings are as long or slightly longer than the elytra and these forms may make short flights. The females are cinereous, quite heavily irrorate with fuscous, while the males are still darker, appearing in extreme cases as smoky. Length, females, 5–6 mm.; males, 5 mm.

Described from two pairs from Fort Collins, Colorado. Taken by the writer from under the clumps of *Schedonnardus texanus*, a "short grass" clump common on the plains. The larvæ were taken into the laboratory in May. The adults emerged in late May and June. This is remarkably early for this group and appearance might be taken to indicate two generations, but is probably only an adaptation to the early maturity of the buffalo grass and the other short grasses. This variety is quite remarkable in the whole *Gypona* group and superficially resembles an *Acocephalus* or even a *Penthemia*. When compared with the giant variety *ponderosa* it looks like a veritable pigmy. One wonders whether both size and early maturity are not adaptations to "short grass" conditions.

2. **Gypona (Prairiana) miliaris** Stal.

Gypona fraterna Spangb.; *Gypona negotiosa* Gibs.

This species resembles *cinerea* in general form and like that species is widely variable in size and color. The vertex is

shorter and less angled and the front is distinctly shorter and broader. The females are usually much longer and lighter colored than the males, grayish cinereous with minute fuscous spotting. The males are usually heavily irrorate, with fine brown points on vertex and pronotum, while the elytra are brown with the veins lighter and milky spots irregularly distributed in the cells.

This species occurs along the Atlantic and Gulf coast from Connecticut to Texas and Mexico. It does not seem to be a common species far inland, except possibly in the South. A single male from Chicago has been examined. It is probable that the eastern records for *cinerea* all belong to this species and that these two species scarcely if at all overlap in range.

3. **Gypona (Prairiana) fraudulenta** Spangb.

Gypona marmorata Fowl.

Resembling *miliaris* in general form, but with the ocelli widely separated, and the antennal sockets touching the eyes. Golden yellow, heavily ornamented with brown and fuscous as follows: A line under the vertex margin, a pair of round spots on the vertex behind the ocelli, irregular markings on the anterior portion of the pronotum, two lines on the scutellum and irregular lines in the areoles. A single female from Glen Echo, Maryland, is at hand.

This species is somewhat intermediate in character between *Gypona* and *Prairiana*, but until the whole group is worked up and its affinities established, it should remain in the latter genus.

Spangberg, page 59, of Species Gyponæ, describes a species as *marmorata* that is quite different from the one Fowler described so his name would fall in any case.

Subgenus **Ponana** n. sub. gen.

Resembling *Gypona* in general appearance, the body inclined to be cylindrical rather than so definitely flattened. Vertex often much shorter than wide, usually convex, with a rather definite depression before the thickened anterior margin, which is usually indicated above and below, but not produced more than its own width. Vertex and front meeting in nearly a right angle. Ocelli on the disc before the middle. Elytra long and narrow, closely folded. Venation regular.

Type of the subgenus *Gypona* (*Ponana*) *scarlatina* Fitch.

This genus includes a larger number of the blunt headed members of the old genus *Gypona*. The depressed vertex and the thickened margin between vertex and front will at once separate these forms.

Key to the Species of Ponana.

A. Vertex moderately long and narrow. Species frequently sprinkled with sanguineous.
- B. Elytra unmarked or with few markings in areoles and those mostly transverse..1. *scarlatina* Fh.
- BB. Elytra with numerous markings in the areoles either dots or lines parallel with the nervures.
  - C. Elytral nervures margined with fine dots.
    - D. Small species with head short............2. *curiata* Gib.
    - DD. Species long and narrow, with larger head..3. *dohrni* Stal.
  - CC. Elytral nervures not margined with dots.
    - E. Fuscous dots numerous.......4. *sanginolenta* Spgb.
    - EE. Sanguineous markings only.......5. *irrorata* Spgb.

AA. Vertex broad and short ocelli well before the middle.
- F. Nervures light margined with brown ocelli definitely back of margin. Pronotum brown with numerous spots on anterior margin. 6. *marginifrons* Fowl.
- FF. Nervures brown. without margins. Ocelli against the rounding margin. Pronotal spots only behind eyes............7. *resima* Fowl.

1. **Gypona (Ponana) scarlatina** Fitch.

This species which Fitch described briefly but accurately in 1851 is one of the most variable of the North American forms, both in color and markings. It varies from almost black to a very light green through shades of olive, brown and scarlet and with equal variation in spots and marks in such numerous patterns that it has been described at least 21 times.

Through all this variation it is a moderate sized active species with a rounding vertex, longer in the middle than against the eye, a definite margin except in the pale forms. The ocelli are before the middle and considerably farther from each other than from the eye. The female segment is very slightly produced and scarcely sinuated. While the male valve is very large, rounding posteriorly with a definite medial callosity back of the margin and often a median carina. The plates are long, separate, curved somewhat like corn husks. They extend at an angle from the pygofers and thus open to view two caliper-like hooks. This and the large ivory posterior lobe of the scutellum are the two most constant characters in the species. The dark markings when present in the elytral areoles are unique in

being inclined to be transverse lines and the spots on pronotum are nearer the anterior margin than those in the preceding groups. While intermediates of various kinds occur, the great majority of the examples fall readily into the following varieties.

Var. **limbatipennis** Spangb.

Gypona albimarginata Woodw.

Vertex and pronotum fulvous, the narrow posterior margin of the pronotum and all of scutellum and elytra, except the narrow creamy costal margins, smoky brown or black.

Spangberg described both sexes from Illinois. The writer has taken dark nymphs from the base of buttercups in a damp meadow in Iowa and obtained this species from them. Dr. Marshall has taken it in Wisconsin and Gibson reports it from New York. This form seems to be the rarest and shades out into var *pectoralis*.

Var. **pectoralis** Spangb.

Gypona hullensis Prov.; *Gypona bimaculata* Wood.; *Gypona woodworthi* Van D.

Pale greenish yellow, the scutellar disc creamy, an indefinite smoky band arising on posterior margin of pronotum and extending to apex of elytra. A number of irregular black dots on elytra, including a larger and fairly definite pair just back of the center of the disc. A pair of round spots back of ocelli on base of vertex and another pair just behind them are usually faintly outlined in brown. As these spots increase in size and numbers it shades off into var. *puncticollis*.

This is the commonest form of this species throughout the upper Mississippi Valley and extends east to Ontario and the New England States. The writer has taken the brown nymphs commonly from the water sprouts and lower limbs of basswood trees in Iowa and Wisconsin.

Woodworth described a specimen in which the smoky shade had a slightly reddish tinge as *bimaculata*.

Var. **scarlatina** Fitch.

Gypona modesta Spgb.

Pale yellow with a smoky or reddish cast. A number of irregular spots on the disc of the elytra. More or less of scarlet spotting on whole dorsal surface.

This variety is close to *pectoralis*. It is, however, readily separated by the absence of the smoky band and the presence of the scarlet spotting.

Var. **rodora** n. var.

Gypona meditabunda Gib. (not Spgb.)

Uniformly pale reddish above and below, with the usual spots on the disc of elytra. The nervures are reddish instead of irregularly smoky as in *pectoralis* and *scarlatina*. There are sometimes traces of scarlet spotting on vertex and pronotum.

Described from a pair from Washington, D. C. Others are at hand from New Jersey.

Var. **puncticollis** Spangb.

Gypona quadrinotata Spangb.; *Gypona albosignata* Uhl.; *Gypona proscripta* Fowl.; *Gypona hieroglyphica* Fowl.; *Gypona notula* Fowl.

Pale yellowish with reddish cast emphasized on the elytra. A pair of round black spots back of ocelli on pronotum, a pair near each lateral margin behind the eyes, the outer ones larger and a pair on the elytral hinges. The usual spotting on disc of elytra and the narrow line on posterior margin of pronotum. Scarlet spotting often present.

This form replaces *pectoralis* and *scarlatina* in the south and southwest and occurs north to Kansas, Ontario and New York.

Var. **vinula** Stal.

Gypona vinula var. *ornata* Fowl.; *Gypona propior* Fowl.; *Gypona tergata* Fowl.

Pale greenish yellow with the spots and markings of *puncticollis* and with more or less definite smoky or reddish stripe extending from the scutellar margin down the suture to the apex of the elytra. This is a southern form, extending from Virginia and Florida to Vera Cruz, Mexico. It also resembles and intergrades with *pectoralis*, but is usually smaller and like the other southern forms inclined to a more inflated head.

Var. **citrina** Spangb.

Gypona pauperata Spgb.

Almost uniform yellowish with a few black spots on the disc of elytra and sometimes faint ones on pronotum. *G. pauperata* was described from an example with scarlet spotting.

This is a southern form, common in Florida and Texas and extending up the Atlantic coast as far as Washington, D. C.

Var. **meditabunda** Spgb.

Gypona cacozela Gib.: *Gypona occlusa* Gib.

Greenish or greenish yellow with the costal margin of elytra creamy and the appendix smoky brown. The hinge has a

black spot in both sexes. The males sometimes have the two median black points on pronotum and a few on disc of elytra. The head is similar to that in *citrina*, but shorter with the margin even more rounding in some examples.

Spangberg described this form from Texas and gave its color as greenish yellow with a brown appendix. He compares it to *flavicosta* Stal, which has a very short head. Gibson placed this name on a reddish form apparently common in Maryland and New Jersey (see var. *rodora*) and described the true *meditabunda* as *cacozela* and again as *occlusa*, but separating them in the key by the absence of the spot on hinges in *cacozela*, but in the descriptions he gives "elytra with base of clavus darkened" in both cases. As has been shown above, this character is widely variable. All the examples of this form seen have been from Texas. The writer has three examples from Brownsville and one from San Diego, Texas, while all of Gibson's material was from Brownsville.

2. **Gypona (Ponana) curiata** Gib.

A small, dull brownish species with blunt head, faint markings on elytra and the nervures bordered with fine punctures.

Gibson's material was from Arizona.

3. **Gypona (Ponana) dohrni** Stal.

Gypona punctipennis Stal.; (?) *Gypona bisignata* Fowl.: (?) *Gypona reservanda* Fowl.; *Gypona aquila* Gib.

A long, slender testaceous or grayish brown species superficially strikingly resembling *Phlepsius majestus* Osb. and Ball. The front is transversely lined with brown, the vertex is almost parallel margined, the ocelli are before the middle and twice farther from each other than from the eyes. There are black spots behind the ocelli, pot-hooks and spots on the anterior sub-margin of the pronotum. The elytra are long, narrow and inscribed with fuscous marks in the cells, with one or two larger ones behind the middle, while the nervures are margined with fine fuscous dots.

Examples are at hand from Grand Junction, Colorado, the Huachuca Mountains, Arizona, and Stal described it from Mexico. It is probably confined to the Rocky Mountain region. Fowler did not recognize either of the Stal species, but apparently described it twice.

4. **Gypona (Ponana) sanguinolenta** Spgb.

Gypona grisea Spgb.

Resembling *dohrni* in general appearance, but with a slightly longer flatter vertex and lacking the marginal punctures to the nervures. There are two median punctures on the claval veins, fuscous. The posterior half of pronotum thickly and the areoles sparsely irrorated with brownish points.

Spangberg described this species from Texas and Georgia. It has since been taken as far north along the coast as Pennsylvania and Massachusetts. Spangberg based the difference between *grisea* and *sanguinolenta* upon the latter having the scarlet flaking, a character in which all variations occur in several species.

5. **Gypona (Ponana) irrorella** Spgb.

Gypona scarlatina Gib. (not Fitch); *Gypona grisea* Gib. (not Spgb.)

This species resembles *sanguinolenta* in form and structure but lacks the dark markings of that species. In place of other markings the entire dorsal surface is irregularly flaked with scarlet.

This is a southern species occurring from Texas north and east on the Atlantic coast to Massachusetts but in the interior apparently south of the Ohio River line to Kansas.

Gibson identifies northern examples of this species as *scarlatina* Fitch and refers to a "Fitch type." This type was undoubtedly one of the many "Fitch types" in the National Museum that are not true to type at all in either characters or labels. The writer recently examined the Fitch types at Albany and found that practically all the material of his catalogue was still intact and except for some fading answered perfectly to description and label. Gibson apparently overlooked the fact that Fitch's description calls for black dots on the elytra for he says "but elytra lack the black dots as in *sanguinolenta*." Fitch's material came from Salem, New York, at the base of the Adirondacks which is probably out of the range of this species but in a district where true *scarlatina* and its varieties are common.

G. grisea of Spangberg is described as having heavy black spotting and no red flaking. Gibson on the contrary, sets off two large specimens of *irrorella* without dark markings but with heavy scarlet flaking as representatives of this species.

It is possible that the study of life histories or of more abundant material will show that this and the two preceding species are but variations of a single species which will then be called *dohrni* Stal.

6. **Gypona (Ponana) marginifrons** Fowl.

This testaceous brown species with its broad, short vertex, dark spots and lines on the anterior part of pronotum, and light elytral nervures narrowly margined with brown is a strikingly distinct and easily recognized species.

The female segment is short with acutely produced lateral angles, between which the posterior margin is obtusely angularly produced and black tipped.

The writer took this species at Dolores, Colorado, feeding on *Rhus trilobata* or a closely related species and other examples are at hand from Arizona. Gibson reports it from New Mexico, while it was described from males taken in Mexico.

Fowler places this species in his group with foliaceous vertices although his own description and figures show that it belongs in the other group, in fact, it is closely related to the species with the shortest and most rounding heads.

7. **Gypona (Ponana) resima** Fowl.

Gypona bipunctulata Gib. (not Woodw.); (?) *Gypona celata* Fowl.; (*Gypona intertexta* Uhler Mss.)

This pale cinnamon brown species can be readily separated from all others in our fauna by the short, obtusely rounding vertex with the widely separated ocelli placed just back of the rounding margin. It resembles *marginifrons* but lacks most of the pronotal markings; varying from none to two behind each eye, the outer one large. The veins are definitely brownish and the cross veins are slightly marked with fuscous. All the specimens examined from our territory have been from Georgia, Florida and Mexico and it is probably limited to a narrow gulf area in the United States.

Fowler describes *resima* without spots on pronotum but he had only female examples, while *celata* was described from females from Central America as with or without pronotal spots. *Gypona nana* Fowler which appears to be closely related is described as with or without spots.

Gibson's reference of this species to *bipunctulata* Woodw. must have been an over sight as that species was founded on the big, broad, green female of *melanota* and was so described. The writer has examined the Woodworth material (he made no types) in the Illinois Collection and found *bipunctulata* Woodw. and *nigra* Woodw. to be the sexes of the species here listed as *melanota* Spgb. and very distinct from the species described above. Gibson's material was apparently all from Georgia and Florida and the only excuse for the wide range given was probably the supposed Illinois record of Woodworth.

NOTES ON OTHER SPECIES OF GYPONA.

In working over the Mexican species in the course of this study *Gypona atitlana* Fowl. and *abjecta* Fowl. appear to be synonyms of *mystica* Spangb., a species described from Mexico but which Fowler did not recognize.

The writer has in his collection four South American species that resemble *melanota* in their color variations. *Gypona glauca* Fab. the type of the genus possesses males varying all the way from the color of the females to shining black. Some of the intermediate forms are highly ornamented with variable patterns of alternate yellow and black. *Gypona vulnerata* Walk, *viridescens* Walk. and *obsesa* Spangb. are variations of one species while *postica* Walk. appears to be the extremely dark form of the male. *Gypona thoracica* Fab., one of the largest species of the group, varies from brilliant green and smoky in the female through all changes and variations of bright red and shining black in the male.

THE WINTER OF 1918-'19 AND THE ACTIVITIES OF INSECTS WITH SPECIAL REFERENCE TO THE CLOVER LEAF-WEEVIL

(**Hypera punctata** Fab.)

GLENN W. HERRICK.

Our knowledge of the factors governing the ability of insects to pass successfully through any given winter conditions is very meager. Apparently some winters are very destructive to insect life and bring about a high mortality in the stages that attempt to survive this period while other winters are favorable to the survival of the eggs, larvæ, pupæ, or imagos as the case may be. The winter of 1918–1919 was certainly a very open and abnormally warm one all over New York State; but it is apparent, from studies made regarding the effect of heat and cold on insect life, that the comparative degrees of humidity, as well as of temperature, must be taken into account if correct generalizations are to be made. For example, as Pierce[1] says: "A creature which can stand a certain degree of cold at a given humidity may be absolutely unable to stand that same temperature at another degree of saturation or relative humidity." Thus there have arisen conflicting interpretations of climatic effects on insects made by different investigators in different localities because they were working under very different degrees of humidity of which no account was taken. It will perhaps not be out of place to give a brief summary of the weather conditions from November to April inclusive as recorded by the weather station at Cornell University:

NOVEMBER, 1918.

"Weather conditions throughout November, 1918, were warm and pleasant, for the most part, with average temperatures generally above the normals in all sections, but the month was a very dry one in all districts, except at few points in the northern part of the State."

DECEMBER, 1918.

"Reports from all sections show that the month was unusually mild with an average excess of warmth of about four and one-half degrees, which is in marked contrast to the severe December of a year ago. A brief spell of zero weather was experienced in the Adirondacks during the first week and again in the northern counties during the

closing days, but otherwise conditions were generally mild and favorable for all forms of outdoor work. Snowfall and precipitation amounts were generally below the normals but were well distributed."

JANUARY, 1919.

"Weather conditions throughout the month were exceptionally mild, as a rule. Two cold spells occurred during the first half of the month, the temperature falling to —20° to —27° in the Adirondack region on the 10th, 11th and 12th, while in the southern and southeastern sections it ranged from 9° to about —15°. Fortunately the ground was fairly well covered with snow during these severe cold spells, affording a fair to good protection to winter grains, meadows, and new seeding. After the 15th the ground was generally free from snow in most sections, but the temperature average was abnormally high for the season. * * * * Precipitation and snowfall amounts were below the normals at all but a very few stations and pleasant overhead conditions usually obtained."

FEBRUARY, 1919.

"February, like January, was above the normal in temperature and below normal in precipitation. With the exception of 1915 when the temperature averaged 0.3° higher, this was the warmest February since 1891, while precipitation was below normal in all sections, the average of 1.89 inches being the least recorded in the month of February since 1907."

MARCH, 1919.

"The weather of March, 1919, was somewhat above the average both in temperature and precipitation, the excess being 3.4° and 0.56 of an inch respectively. The temperature was above normal in all sections of the State. * * * * The precipitation was above normal in all sections except the Western Plateau and the Mohawk Valley, where it was slightly deficient."

APRIL, 1919.

"The month as a whole, while somewhat colder than the average April, was remarkable for two decidedly cold periods of three days each. The first period covered the first three days of the month, and the second occurred from the 25th to 27th inclusive. The month opened decidedly cold for the season with maximum temperatures generally but little above freezing and minimum temperatures approaching zero in the more elevated parts of the State. * * * * The monthly precipitation for the State was considerably above average."

The weather conditions for the winter of 1918–'19 in New York State may be summed up then as being *above the normal* in temperature and somewhat *below the normal* in precipitation and what is probably as important as either of these there were no

extremes of temperatures except two short cold spells in January when the ground was fairly well covered with snow.

Another factor that must be taken into consideration in any account of the activities of insect life during the season of 1919 is the character of the climatic conditions of the summer following the winter of 1918–1919.

The summer of 1919 was one of normal averages for the months of July and August although there were extremes in July largely because the thermometer went very low at one period. May was nearly normal in temperature but the precipitation was above the normal while June was a month of abnormally high temperatures with precipitation somewhat below the normal and this may have favored the early increase of insects. As a whole, the summer, from a human standpoint, was pleasant and comfortable and a very favorable one for crop production.

The writer is well aware of the danger of making generalizations regarding this phase of insect life. The factors are too involved and there are too many conflicting conditions to make possible any extended generalizations. It is rather commonly held, I think, that insects can better withstand winters with steady low temperatures than seasons of sudden, wide, periodic fluctuations of temperature. We shall probably find, when we have sufficient accurate data, that insects can best withstand winter or summer conditions of even or equable average temperatures accompanied by certain optimum conditions of humidity.

There have been seasons when one or two insects, like the army-worm, May-beetles, rosy apple aphid and green apple aphid have been very abundant but as the author looks back over the last half-dozen years he does not recall a season within that period certainly when so many different species of insect pests were so generally prevalent and destructive as during the past summer. For example, the red-legged grasshopper, *Melanoplus femur-rubrum*, was abundant and destructive over a large part of the State. Say's blister beetle, *Pomphopœa sayi*, appeared in destructive numbers from Utica to near Buffalo. The little black and red Hemipteron, *Cosmopepla carnifex*, a weather barometer apparently, appeared in enormous numbers in several localities. The wheat midge, *Contarinia tritici*, was abundant and injurious over the whole State, while the green

clover worm, *Plathypena scabra*, occurred from Long Island to Lake Erie and was destructive to vegetables. The old-fashioned potato beetle, *Lema trilineata*, came into prominence for the first time in many years while that other increasing potato pest, the potato leafhopper, *Empoasca mali*, was present in injurious numbers in many localities. The pear slug, *Eriocampoides limacina*, became abundant in certain regions and, in one instance at least, nearly defoliated five acres of cherry trees. The lined corn-borer, *Hadena fractilinea*, scarcely heard of since Webster discussed it in 1894, appeared generally over the State and caused considerable injury. Other examples might be mentioned, but we wish to speak more specifically of the clover leaf-weevil, *Hypera punctata*, and its activities in the spring of 1919.

In some localities the clover leaf-weevil had evidently passed the winter very successfully and in large numbers, and what interested me most regarding it was the numbers of fresh active adults that we found in the fields in the spring. The larvæ were abnormally abundant in many fields in the State and in one or two localities bid fair to cause serious injury. On a farm near Warsaw, N. Y., in a field of eight acres of clover sown the year before to wheat, the larvæ occurred in enormous numbers and for a time devoured the clover about as fast as it grew. On May 17 I visited the field and found the larvæ in all stages of growth although many were nearly full-grown. From six to eight grubs were present at the base of each plant but the conspicuous thing about them at this time was the large numbers of individuals that were dead or dying from the attacks of the fungus *Empusa sphærosperma*. The sick larvæ had climbed the blades of grass, stems of clover, and stubble of wheat around which each had curled in the characteristic horizontal position. The larva would turn white at first but later would become green and soon die. The progress of the larvæ and of the disease to which they were subject was watched by D. S. Dilts, Assistant Farm Bureau Agent. He informs me that the grubs were so effectively checked by the fungus that they caused no material damage after the middle of May and that the clover recuperated from the early injury and made a fine growth. Similar conditions were observed here at Ithaca. Other observers have recorded the effectiveness of this fungus in holding the larvæ in check in seasons of abnormal abundance. For instance, Folsom[2]

says "the reported outbreaks of the larvæ in spring have almost always been suppressed by the virulent disease just described (*Empusa*). This disease prevents the summer damage by the beetles, often killing the larvæ before they have done much injury."

Perhaps the most striking feature regarding the weevil was the number of adults that came through the winter in an apparently active condition capable of procreating the species. It is generally supposed that the weevils, although they may survive the winter, are not capable of any activity in the spring. Indeed all that I have ever found hitherto in the spring have been more or less covered with dried mud and were weak and apparently incapable of effectual activity. On this point Folsom[3] says: "I have rarely found the beetles in the early spring, and such as were found were either dead or in the last stages of decrepitude, and evidently incapable of doing anything toward the propagation of their kind."

My attention was first called to these adults by Mr. J. D. Detwiler, who was in the field searching for species of some lesser clover weevils on which he is now working. On March 26 he brought in three adult weevils which were fresh and clean of dirt and active in movement. On succeeding days we were able to find more adults in similar condition. It seems probable that the weevils were similarly abundant and active in the spring in clover fields throughout the State. These beetles were placed in a cage until other beetles were collected in the next few days and on April 5 cages were made ready and the beetles placed in them. The weevils were furnished with fresh clover plants and pieces of old clover stems to provide hiding places for possible eggs. On April 7 I found seven fresh eggs in a hollow clover stem. In another cage, also on April 7, I found one egg on the stipule of a leaf. All of these eggs were removed and placed in shallow tin boxes but owing to dryness, I think, every one of them shriveled and failed to hatch.

On April 19 a group of nine or ten fresh eggs was found again in one of the cages. Again they were deposited in an old hollow stem of clover. These eggs hatched on May 6 or 7. I am not sure which, because at my last examination on May 5 they had not hatched and owing to my absence I did not see them again until the morning of the 8th, when all had hatched. From these eggs I isolated several larvæ, placing each in a shell vial

where they could be watched and fed. Later, when the larvæ became of some size each was transferred to a shallow tin box.

On April 21 I found another batch of nine eggs in a hollow clover stem. Unfortunately, in my desire to watch these closely I opened the stem and later the eggs became scattered in the cage. Those that I could find, however, hatched about May 7. Another batch of eggs found sometime after deposition hatched May 18. In all, four or five batches of eggs were obtained from these beetles.

The lives of the larvæ placed in vials, and later in tin boxes, were somewhat checkered, as one died within a short time, another after the first molt and a third after the second molt. Three, however, came through but one pupated, without spinning a cocoon, on June 8 (I found this to be quite a common occurrence in the tin boxes) and the beetle died without emerging. Another spun a cocoon on June 8 and the adult emerged June 20. This gives a period from egg to adult of 44 or 45 days, depending on whether the eggs hatched May 6 or May 7. A third pupated naked on June 14 and the adult emerged June 20.

From eggs in another cage found May 5 and that hatched May 18, I isolated three larvæ of which one died while two passed through their cycle and both pupated on June 14, while the weevils of both appeared on June 20, only a few hours apart. This would give a cycle of 46 days (from May 5 to June 20).

The vicissitudes of breeding experiments are many, especially where an attempt is made to isolate each larva and to rear it under abnormal conditions. If the larvæ had been left in the cages in more normal environments they would probably have come through more succsesfully. Indeed, in one of the cages in which I failed to find the eggs and therefore did not remove them the larvæ throve much better. In view of the foregoing facts regarding egg-laying and development of the weevils the question of a possible second generation presents itself.

Riley[4] who first investigated this insect in 1881 and '82, says: "This fact, together with the other well-known fact that the Rhynchophora in the imago state are often long-lived and do not begin ovipositing immediately after maturity leads us to believe that there is normally but one annual generation." He qualifies this statement later, however, by saying that "our notes and observations as here recorded would indicate that a second generation may exceptionally occur," and suggests that this might

happen in the latitude of Washington, D. C. Folsom[5] says: "In central Illinois we have only one annual generation of this insect, as seems to be the rule elsewhere," and later he also says: "In a warmer latitude than this there might very well be a second generation of beetles, to hibernate and lay eggs the following spring."

It seems to me that our observations and breeding experiments show fairly conclusively that the clover leaf-weevil may survive favorable winters and become active enough in the spring to deposit eggs thus producing exceptionally a second generation in central New York. It will be recalled that November of 1918 "was warm and pleasant for the most part" and that "December was unusually mild with an average excess of warmth of about four and one-half degrees." These conditions may well have given opportunity for many of the larvæ to have reached maturity in the fall and to have transformed to beetles which found favorable weather conditions, during January, February and March. Thus they were able to pass the winter without impaired vitality and deposited eggs in the spring. Moreover, these observations, it seems to me, indicate strongly that farther south where the winter conditions are habitually more favorable, there may be normally a second generation of the weevils.

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SOME OBSERVATIONS ON INSECTS OF THE BETWEEN TIDE ZONE OF THE NORTH CAROLINA COAST.

By Z. P. Metcalf and Herbert Osborn.

An opportunity for a brief study of the ecological condition prevailing at Wrightsville Beach near Wilmington, N. C., resulted in the determination of the ecological adaptation of several species of Homoptera which have either been entirely overlooked or so little studied that a record of our observations seems worth while. The particular and very interesting ecological situation common of course to long stretches of the Atlantic coast but admirably exhibited at Wrightsville Beach lies in the between tide zone of the inner beach adjoining the sound. This differs from the outer beach facing the ocean in that it is not subjected to the severe wave action of the exposed coast while it gets the full benefit of the rise and fall of the tides. This results in a most luxuriant growth of tidal grasses which are fully adapted to submergence some of them at levels where the whole plant is submerged for hours at a time other species less completely submerged and merging into the zones of Uniola which for the most part appear to be above the level of the high tides although the roots and at time portions of the stems are no doubt under water.

These grasses support a multitude of insects among them many Homoptera and these were the objects of our special attention. The most abundan tof these were the delphacids (*Liburnia detecta*) but there were other fulgorids, some jassids and one species of cicadid. These insects are fitted in varying degrees to survive the periods of submergence to which they must be subjected but all must have undergone some modification in habit and probably in life history if not in structure to fit them for this mode of life.

It certainly seems rather novel to find these strictly aerial, normally terrestrial insects associated with fiddler crabs and seasnails and maintaining themselves under all the exigencies of tidal forces and alternating aerial and aquatic life. Notes on some of the species observed will illustrate some of the adaptations.

Tibicen viridifascia Walk.

Adults of this species occurred in the grasses of the tidal flats of the Wrightsville Beach on the bay side of the dunes and in many instances the specimens taken were at points evidently below the high tide level. Pupæ were found in considerable numbers attached to the grasses well below the level of high tide and very evidently where they had been attached for the emergence of the adults. Holes were observed at points well below the high tide level which had every appearance of being the openings from burrows which had been occupied by nymphs as they were in the same localities where exuviæ were clinging to the stems of grass. Further there were many pupal cases in the drift and these would appear much more likely to have come from a level below tide than above as otherwise it would have been necessary for the cases to have been dislodged from the grass and blown to the surface of the water. From these observations we feel warranted in the conclusion that the nymphal stages of this species are passed in soil that is for a large part of the time under water in fact only exposed at times of low tide.

A little search for egg punctures was rewarded by the finding of such punctures in the stems of the Uniola which had every appearance of Cicada punctures and later these were proved both by dissection of eggs from females and on hatching to be such. The egg punctures occurred mostly at a height of two to three feet above ground and in the third or fourth internode of the stem and for all observed at such a level that they were above the level of high tide unless possibly for exceptional high tides. The fresh punctures which were the most abundant ones found occurred in the old stems of the grass apparently stems of last year's growth but in one instance an internode of an old stem contained egg punctures apparently of a former year as well as fresh ones just completed.

The adults fly promptly when disturbed.

The *Cicadellidæ* are essentially plant feeding insects adapted to living upon the leaves or stems of their food plants and the species occurring on the tidal flat grasses have undoubtedly adjusted themselves to this condition from ordinary habitats, in all probability simply following the host plant as it has become adapted to this special ecologic condition; an adaptation for both plant and associated insect that must represent the play of ecologic forces through a great lapse of time.

Deltocephalus littoralis Ball.

This species described by Ball in 1905 from specimens collected by VanDuzee at Anglesea, N. J., and since reported from several localities along the Atlantic coast was taken in considerable abundance at Southport, July 28th (1919) and under conditions which showed its adaptation to the between tide habitat very satisfactorily. The grass upon which it occurred was common in certain parts of the tidal flat and where the sugmergence under high tide was very evident although there was not the indication of such complete submergence as where the *Liburnia detecta* was most common. Adults were abundant and also a nymph which is certainly the young of this species as it was the only nymph of a jassid taken in this association and possesses the distinctive characters of the species so evidently that even without rearing we feel assured of its relation to the adult. These nymphs are quite uniformly greenish yellow without marking except that the eyes appear conspicuously black and the frontal arcs are fairly indicated in whitish on a pale smoky brown background. The length is 2½ mm. It seems obvious that the nymphs and probably the adults also, which showed little tendency to flight, are able to survive considerable periods of submergence and that the species is distinctly restricted to the tidal zone or the grasses occurring there. No record of the occurrence of the species at points incompatible with this view have been made so far as we are aware.

Deltocephalus marinus n. sp.

Another species perhaps even more perfectly adapted for the submergence was taken at Wrightsville Beach, July 27th (1919).

This is a minute species found on a very fine-leaved grass that occurs in extensive mats on areas that are completely submerged at high tide and as the grass is very short it would seem certain that the insect must undergo complete submergence for considerable periods. It corresponds very closely in habitat to the *D. minuta* VanDuzee which abounds in the tidal flat matted grasses of the Pacific coast, especially in the vicinity of Long Beach, California. Our species is much darker above bearing some resemblance to a small *compactus* or to a minute and dark colored *nigrifrons* Forbes (balli VanD.).

The grass on which this species was found, the species undetermined, is apparently restricted in its occurrence and from the patches observed would seem to favor the little depressions or pockets protected from the more violent action of the waves but still sufficiently drained to become fairly dry during the period of low tide.

There is every reason to assume that the whole life history is associated with this grass and although we have not had opportunity to determine as to place of egg deposition or the development of the young we are confident that all these stages will be found associated with this plant when the necessary observations can be made.

As the species appears to be undescribed a technical description is appended.

Deltocephalus marinus n. sp.

A small, slender species, soiled yellowish white in color, with the margin of vertex marked by two or three pairs of fuscous spots. Length 2.25 mm.; width across prothorax .6 mm.

Vertex bluntly angulate, slightly convex, scarcely twice as long on middle as between the eyes, front broad, evenly curved to base of clypeus; pronotum narrower than the head, well produced in front between the eyes, lateral edges rounded, without distinct angles, posterior margin slightly sinuate; elytra extending beyond tip of abdomen, venation distinct.

Color: head yellowish white marked with dark fuscous as follows: eyes, two oblique dashes between eyes and median line, sometimes a pair of large triangular fuscous spots bordering anterior margin of vertex with dots below near the eye as in balli, and seven pairs of heavy arcs on front. Pronotum soiled whitish with six faint longitudinal stripes; elytra soiled whitish, veins lighter with more or less fuscous border; legs yellowish the femora crossed by two fuscous bands, one near the middle, broad and another between the middle and the apex; abdomen beneath blackish fuscous with pleuræ and genitalia more yellowish.

Genitalia: Female last ventral segment short, about three times as broad as long, posterior margin slightly concave; pygofers rather slender and slightly exceeded by the ovipositor. Male last ventral segment narrow with the apex rather deeply concave, valve broadly triangular, rounded at tip, plates long, two to two and one-half times as long as basal width, gradually tapered to a sharp pointed, upturned and black apex.

Described from 13 males and 14 females collected on small grass below level of high tide Wrightsville Beach, North Car-

olina, July 27, 1919, H. Osborn and Z. P. Metcalf. Type material in collections of authors, North Carolina State College and Ohio State University.

What is quite evidently the larva of this species was collected from the same grass at the same time. Head characters are similar, the general body color is soiled yellowish white, the frons is marked by fuscous arcs and the eyes are blackish fuscous; each segment of the abdomen above from the second to the sixth is bordered by four rectangular black points which are separated from each other by a median white line which runs the length of the abdomen, and also extends forward as a broken stripe over thorax and extends forward on the vertex where it widens anteriorly and fades out near the apex, and by two rows of whitish spots either side of the middle line.

Dictyophara microrhina Walk.

Adults of this species were taken in considerable numbers from beach grasses at about the level of high tide. There was no evidence of their being adapted to complete submergence and as the species occurs on rank lowland grasses away from the coast there is evidently no restriction to the aquatic habitat. The species, however, illustrates the persistence of an insect in following its food plant into conditions of life that must be quite dissimilar from those under which it first formed the association.

Acanalonia pumila VanDuzee.

This species was taken in the same association as the *Dictyophara microrhina* and there is apparently the same or very similar adaptation to the condition prevailing at the high tide line. Among the examples taken were a number which instead of the normal green color were of a dull straw color closely resembling the color of the dead leaves of grass. No evidence as to the place of egg deposition or concerning the early stages was secured but it would seem very probable that the eggs must be laid in such positions that they would be exposed to the submergence at periods of unusual high tide if not in ordinary high tide.

Myndus enotatus VanDuzee.

This species was taken at Southport in a tidal flat much of which was covered with a rather coarse grass and in which *Deltocephalus littoralis* was found in abundance. All specimens of the Myndus secured were in the adult stage and no data was secured as to the larval stages. Inasmuch as *Myndus radicis* Osb. occurs under the surface of the ground and on the roots or crowns of grasses growing in low ground notably, so far as observed, in a river bed subject to periodical overflow, it will be a matter of interest to determine if possible whether the nymphal stages of *enotatus* have a similar habit in the tidal flats.

VanDuzee says of *enotatus:* "This form was swept from the grass on the prairies at Haw Creek in untold thousands and in lesser numbers at other localities farther south," but nothing is said to indicate their occurrence in areas subject to inundation.

The species is recorded in VanDuzee's Catalogue for "Georgia and Florida," so the North Carolina record gives it a considerably wider range. Specimens in the Ohio State University Collection from Bay Ridge, Maryland, collected by Prof. J. S. Hine, appear to belong here also and these would agree with a maritime distribution. Whether the species is strictly limited to one species of grass and this one confined to the tidal flats of the Atlantic coast will need to be determined by further study but certainly the species has been able to accommodate itself to the tide flat habitat and there is little doubt that it is able to undergo periods of submergence lasting for a number of hours. There does not appear, however, to be any structural modifications differing from species occurring where no such peculiar condition prevails and as in other species it would seem that the insect has simply been able to follow its food plant into an unusual environment.

Megamelanus spartini Osb.

This species was beaten from the heads of the common "sea oats" (Uniola paniculata) which fringe the dunes on and near the tidal flats and while we did not find evidence of this species occurring below tide level the close adaptation of the species to its habitat in the heads of the grass and its relationship to species definitely adapted to submerged conditions seem to warrant mention of it here.

It is apparently identical with the form described from *Spartina patens* and collected at Cold Spring Harbor in 1904.*

While the species is very definitely adapted for the conditions of the head with the parts of bloom and seed and none could be secured by beating or sweeping the leaves or stems there is of course an interesting question as to where the eggs may be laid and whether these are liable to submergence from occurring in parts that may at times be under water. The Uniola is for the most part on the parts of the dunes fairly well above high water mark but some of the plants closer to the tide level may very likely be submerged during periods of unusual high tide or severe storms.

Megamelanus elongatus Ball.

Taken only sparingly but on grass of the higher levels of the tidal flats and where the submergence though shorter in duration must be fairly complete.

Megamelus (Prokelesia) marginatus VanD.

A specimen of this species was taken in connection with the abundant *Liburnia detecta* and very evidently fully adapted to the same conditions of life.

It has much the appearance of the Liburnia and may easily be confused with that species especially for the macropterous form.

No details of life history have been recorded and we were unable to carry on any studies that would give definite results as to adaptations in the life history that might be credited to the particular environment of the tidal flats. However, it seems fairly certain that the eggs must be laid in leaves or stems of plants subject to much submergence as otherwise we could hardly account for the abundance of the insects, especially micropterous forms, on plants subject to complete submergence at every period of high tide.

Arndt (1914)† has discussed a number of insects living in the between tide zone and among others gives an account of *Megamelus* (Prokelesia) *marginatus* VanDuzee which is evidently adapted to much the same conditions as the *Liburnia detecta* found at Wrightsville.

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* Ohio Naturalist, Vol. V, p. 375.

† Proc. Indiana Acad. Sci., 1914, pp. 323-336.

In his discussion of the special adaptations for survival under submergence he cites the calcar as a structural modification developed as a reaction to the tidal conditions. To appreciate the absurdity of this inference it is only necessary to note that this structure occurs in all species of Delphacinae and, in many other species having no periods of submergence to contend with in their habits there are fully as large and specialized calcars. Arndt says: "The hoods on its feet, the greatly developed proximal segment and the spur are the peculiar modifications which determined that this leaf-hopper should inhabit this particular region." In all these structures this species is in close accord with the other members of the group. We must look elsewhere for any real modifications of structure.

It should be recognized that these insects and hosts of related forms have been for ages adapted to clinging to the stems and leaves of plants and well fitted for withstanding wind and other forces that might tend to dislodge them. The essential factor that the new environment called for was adjustment to submergence in water and this involves especially the ability to hold sufficient quantities of air in or adjacent to the tracheal system to carry over the periods of submergence.

Liburnia detecta VanD. (=circumcincta VanD. micropterous form).

This species of Delphacid occurred in great abundance on a grass that grew luxuriantly near the level of low tide and where there were enormous swarms of fiddler crabs. At this level the grass must be completely submerged during high tide and for much of the time during the rise and fall of the tide. It is evident, therefore, that the species both as nymphs and adults and doubtless also in the egg stage must be successfully adapted to survive long periods of submergence, several hours at a time at least. The exact method of protection during this submergence could not be determined but from the shape of the insect, both nymph and adult, it would appear that they can crowd themselves into the spaces between leaf-sheath and stem or into the furrows of the leaf blades in such manner as to hold their attachment to the plant, detachment from which would in all probability mean disaster.

It may be added that this species was not found at any point above the between tide zone and therefore its adaptation to this situation is evidently complete and it is probably restricted to the species of grass which is confined to this habitat.

SUMMARY.

Reviewing these facts briefly it may be said that the adaptation to the submergence of tidal flats at some stage of their existence has been acquired by Homopterous insects of several different families, the Cicadidæ, Cicadellidæ and Fulgoridæ and, for the latter, three principal subfamilies that are so widely separated that we may assume entirely independent origin for the habit. In all then, five groups in which the adaptation is present in greater or less degree. Even in the different genera as Megamelus, Megamelanus and Liburnia there is no reason to assume a common origin since many species in each genus are entirely terrestrial.

Each of the species found in this habitat is closely associated with some one species of plant which in turn must be considered as having been derived from a more strictly mesophytic habitat and the conclusion seems warranted that the insect has simply followed its host plant in this adaptation to hydrophytic habitat.

The structural modifications in all the species studied are practically negligible but there is evidently a considerable physiological modification to accommodate the insect to long periods of submergence under water. The structures fitting the insect for close adherence to its plant host were already developed before the aquatic condition was met and if changed at all would only need intensification to provide against the movement of water. No special adaptations for swimming or skimming on the surface of the water are present although these insects, like practically all others when accidentally thrown on water, will float and may to some extent propel themselves over the surface by active movements in jumping or running.

The physiological adaptations which seem probable present a special problem and one which is apparently of considerable interest but we have not had opportunity to follow it up. It may be noted, however, that insects in general, especially when inactive, are able to survive on a minimum supply of air.

EXPLANATION OF PLATES.

PLATE X.

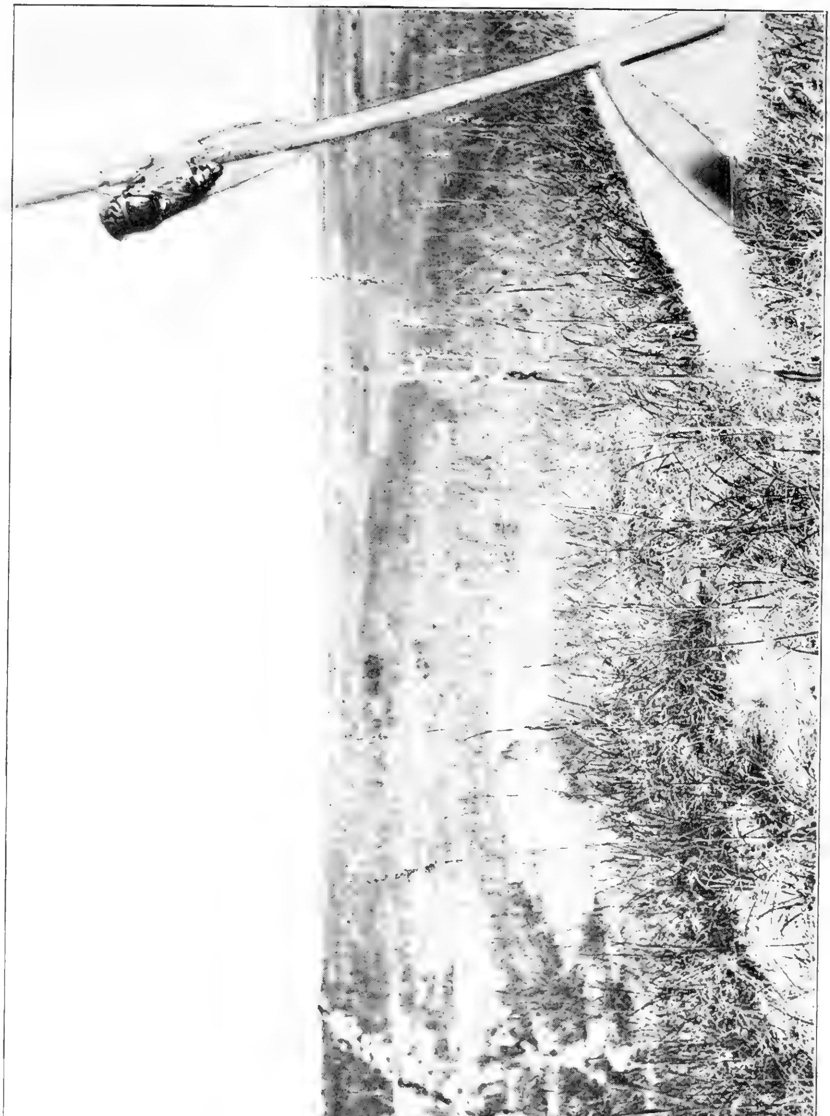
A general view of the tidal flats at Wrightsville Beach, North Carolina, taken from the higher sand dunes. The plants in the immediate foreground are the sea oats. In the right foreground insert is an adult male Tibicen viridifascia Walker resting on a stem of the sea oats.

PLATE XI.

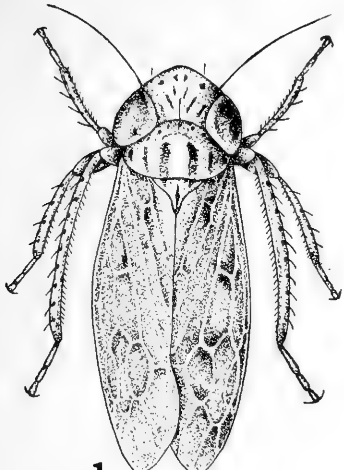
Fig. 1. Deltocephalus marinus sp. n. adult.
Fig. 1a. Deltocephalus marinus sp. n. face.
Fig. 1b. Deltocephalus marinus sp. n. male genitalia.
Fig. 1c. Deltocephalus marinus sp. n. female genitalia.
Fig. 1d. Deltocephalus marinus sp. n. nymph.
Fig. 2. Deltocephalus littoralis Ball.

PLATE XII.

Fig. 1. Acanalonia pumila Van Duzee.
Fig. 2. Myndus enotatus Van Duzee.
Fig. 3. Dictyophora microrhina Walker.
Fig. 4. Liburnia detecta Van Duzee.
Fig. 5. Megamelanus elongatus Ball.
Fig. 6. Megamelanus spartini Osborn.



Metcalf and Osborn.



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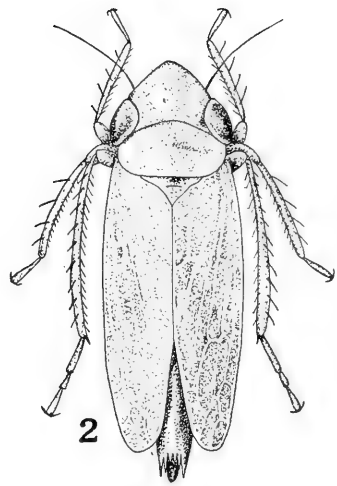

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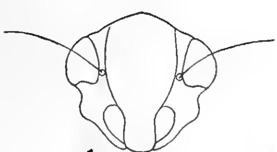

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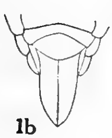

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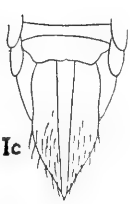

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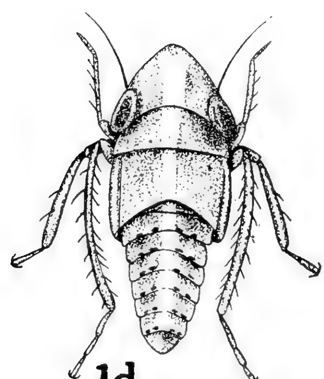

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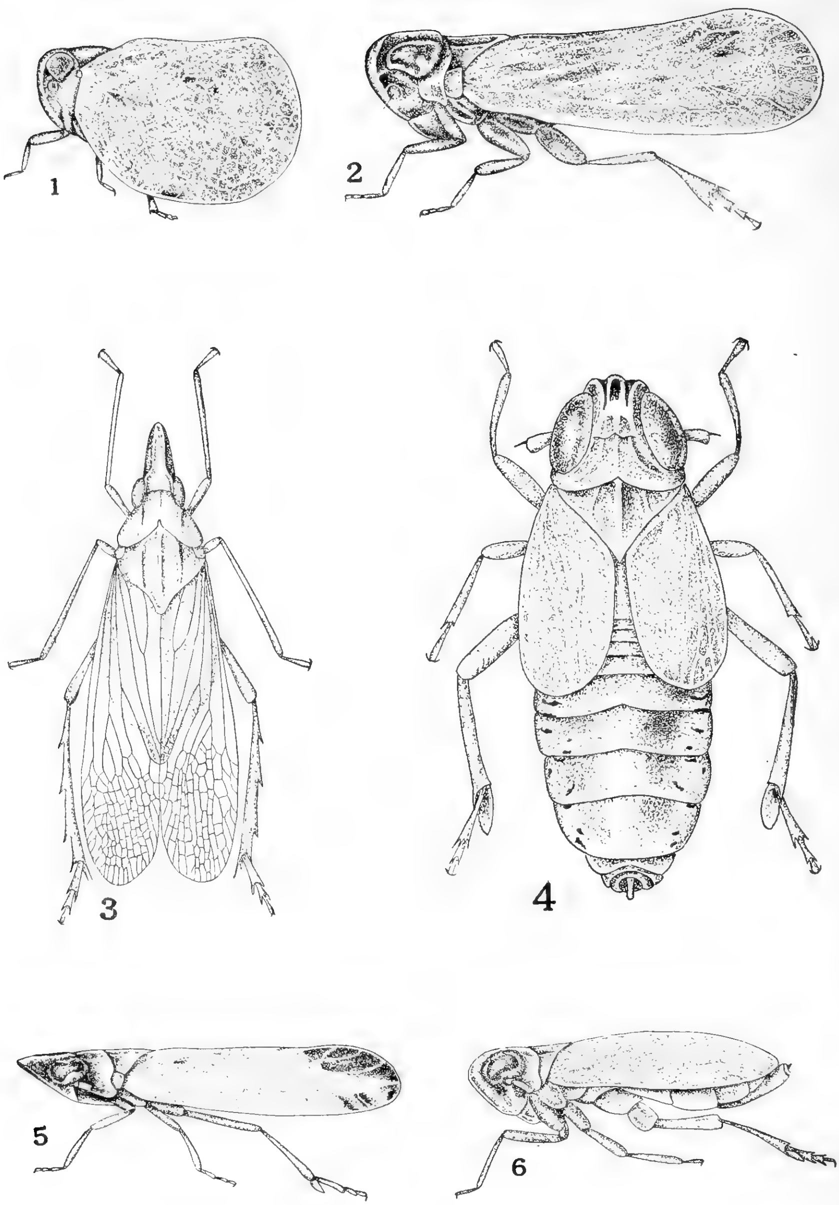
Metcalf and Osborn.



Metcalf and Osborn.

A NOTE ON THE MOUTHPARTS OF THE ARADIDAE

C. S. Spooner.

The members of the heteropterous family Aradidæ are supposed to represent the extreme of dorso-ventral flattening. Certainly they are about as thin as we can imagine possible. We are apt to think that their anatomy, both internal and external, has been modified primarily in this direction. It was with considerable surprise, therefore, that the author, in the course of some morphological studies, discovered a modification of the mouthparts unparalleled, so far as known, in the other Hemiptera and which necessitates considerable dorso-ventral space.

This modification occurs in the mandibular and maxillary setæ and is confined to the interior of the head. The head capsule is somewhat modified to accommodate these changed conditions. It will be noticed (Fig. 1) that the clypeus and labrum, known to systematists as the tylus, is curved ventrad and then caudad in the arc of a circle. The suture separating the clypeus and labrum is obsolete, a difference in texture and flexibility marking its probable position. The lateral edges of these sclerites are incurved and extend a considerable distance within the head. These structures form a semicircular sheath.

The mandibular and maxillary setæ are articulated in the normal position and become firmly interlocked soon after their origin. They are then coiled, within the head, four or five times anti-clockwise, then they bend sharply and reverse their direction, coiling an equal number of times clockwise. They leave the head capsule at the usual place, just cephalad of the labium and lie in the groove along its dorsal aspect. These coils are closely appressed and the cephalic half of the coil is enclosed by the sheath formed by the clypeus and labrum.

The mechanics of this arrangement are simple. A pull on the proximal ends of the setæ would result in the uncoiling of the spring in both directions, forcing the distal end further out of the head capsule. Thus the distance which these setæ may be protruded is limited only by the length and contractability of the muscles concerned.

The total length of these setæ, in *Neuroctenus simplex* (Uhl), is approximately six millimeters. In this species they practically equal the total length of the insect. The extent that these may be protruded is not known. The same arrangement has been found in all species of the family which have been examined, some six species. It is also found in the nymphs.

The biology of these interesting insects is but imperfectly known. Of course, they are found exclusively under comparatively loose bark and supposedly feed upon the juices of

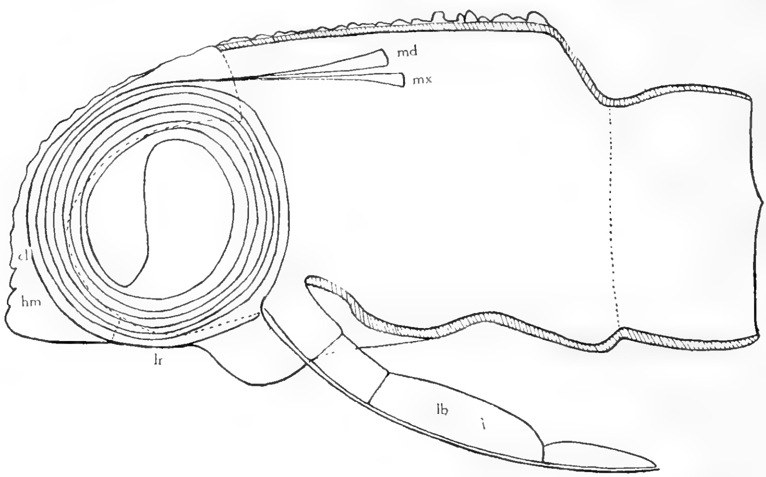


FIG. 1.

Longisection of head of Neuroctenus simplex (Uhl). (Diagramatic). *cl*—Clypeus; *hm*—Hemimaxilla; *lb*—Labium; *lr*—Labrum; *md*—Mandible; *mx*—Maxilla.

decaying wood and bark. Their methods of feeding are unknown, in fact, their very food supply is probably only inferred. We are therefore unable to state what purpose, if there be a special purpose, this modification serves.

It may be well to mention here the fact, as pointed out by Reuter,* that the labium consists of four segments instead of three, as given in most of the American texts and tables.

*Reuter, O. M., Neue Beitrage zut Phylogenie und Systematik der Miriden. Acta Soc. Sc. Fenn. T. 36, No. 3, 1910.

MINUTES OF THE ANNUAL MEETING.

FIRST SESSION.

The Fourteenth Annual Meeting of the Entomological Society of America was opened in Soldan High School, St. Louis, Missouri, at 2:00 P. M., Monday, December 29, 1919, with Vice-President J. W. Folsom in the chair. On motion from the floor, C. L. Metcalf was elected Secretary *pro tem.* The following Committees were appointed by the chair:

Committee on Nominations: RAYMOND C. OSBURN, T. D. A. COCKERELL, and WM. A. RILEY.

Auditing Committee: SEYMOUR HADWEN, C. H. TURNER and J. L. KING.

The Chair appointed ARTHUR GIBSON and GEO. A. DEAN to fill vacancies on the Executive Committee.

This session was devoted to the reading of the following papers:

Tropisms in Insect Behavior—An Inquiry..............C. H. TURNER

The Food Plants and Distribution of Certain Calandra Species.. A. F. SATTERTHWAIT

The Biology of the Carabid Genera Brachynus, Galerita and Chlænius......................................J. L. KING

Insects of the Between-Tide Zone of the North Carolina Coast.... Z. P. METCALF and HERBERT OSBORN

Observations on Canadian Ticks..................SEYMOUR HADWEN

Notes on the Mouth-parts of Aradidæ................C. S. SPOONER

The Genitalia of the Syrphidæ......................C. L. METCALF

Observations on the Genitalia of Lachnosterna.................. WM. P. HAYS and J. W. MCCOLLOCH

Notes on the Leafhoppers of the Subfamily Gyponinæ......E. D. BALL

The Production of Abnormal Larvæ, Pupæ, and Adult Beetles by Gas Secreted by the Confused Flour Beetle (Tribolium confusum)...................................R. N. CHAPMAN

SECOND SESSION.

TUESDAY, DECEMBER 30, 10:00 A. M.

The Society was called to order by the President, J. G. Needham, in Soldan High School at 10:00 A. M. This session was devoted to a Symposium on "The Life Cycle in Insects."

Scope:

1. Facts as to form changes, broods, length of life, moults.
2. Significance of facts in relation to nature of environment, reproductive capacity, rate and times of growth, habits, etc. Briefest possible statement of what each group best illustrates in relation to the life cycle.

Presentation by groups, as follows:

1. Apterygote Insects............................J. W. FOLSOM
2. Orthopteroids (sens. lat.)....................E. M. WALKER
3. Hemiptera (excl. 4)............................E. D. BALL
4. Aphids and Coccids.......................EDITH M. PATCH
5. Neuropteroids having complete metamorphosis, and Lepidoptera...................................S. L. FRACKER
6. Coleoptera (incl. Strepsiptera)................R. N. CHAPMAN
7. Diptera.......................................C. L. METCALF
8. Hymenoptera.........................T. D. A. COCKERELL

Concluding Discussion.........................S. A. FORBES

THIRD SESSION.

TUESDAY, DECEMBER 30, 2:00 P. M.

The Society was called to order in business session in Soldan High School by President Jas. G. Needham.

Dr. F. E. Lutz moved that it is the sense of the Society that it be desirable to have the papers on the Life Cycle in Insects published in one number of the ANNALS. Motion carried.

Motion was passed to hear the papers remaining on the program before the business session. The following papers were heard:

The Influence of Environmental Factors in the Hatching of the Eggs of Aphis prunifoliæ Fitch.................ALVAH PETERSON

Serum Diagnosis and Insect Relationships......................
ROBT. D. GLASGOW and JOSEPHINE BURNS GLASGOW

The Executive Committee presented the reports of the Secretary, Treasurer, Editor of ANNALS, and Treasurer of the Thomas Say Foundation, as follows:

REPORT OF THE SECRETARY.

Membership.—The following members have died since the last Report:

EMERSON LISCUM DIVEN, killed by the fall of an aeroplane while engaged in government work.
V. A. E. DAECKE.
O. S. WESTCOTT.
F. H. WOLLY-DOD, died in army service in the Balkans.
Total, 4.

The following have resigned:

DR. JAS. F. ABBOTT.
GEO. F. ARNOLD.
W. B. BARROWS.
R. P. DOW.
S. W. FOSTER.
MAURICE E. HAYS.
WM. KAYSER.
ALICE A. NOYES.
F. X. WILLIAMS.
Total, 9.
For non-payment of dues, 17 members were dropped.
Total losses, 30.

On September 20th, the following were elected to membership by the Executive Committee:

HAROLD M. BOWER.
P. W. CLAASEN.
F. C. CRAIGHEAD.
JOS. J. E. GILLET.
ARTHUR FRANK.
STANLEY R. MCLANE.
H. RAYMOND PAINTER.
I. L. RESSLER.
BENJ. G. THOMPSON.
COLBRAN J. WAINWRIGHT.
Total, 10.

On December 29th the Executive Committee elected the following:

GEO. H. BRADLEY.
WM. C. COOK.
R. A. CUSHMAN.
A. G. DIMOND.
HERBERT L. DOZIER.
MARVIN DUNN.
ALFRED E. EMERSON.
ROBT. K. FLETCHER.
LAURA FLORENCE.
PERRY A. GLICK.
WM. P. HAYES.
CHAS. C. HILL.
HARRY A. HORTON.
ROBT. L. KING.
FLOYD LAMBERT.
RICHARD N. LOBDELL.
STEWART LOCKWOOD.
PHILIP R. LOWRY.
ENOCH A. MCMAHON.
H. H. NININGER.
R. H. PAINTER.
H. T. SEIFERT.
MARION R. SMITH.
WM. SCHAUS.
HERBERT SPENCER.
J. R. STEAR.
Total, 26.

Total additions, 36. Net gain in membership, 6.

War Service and Remission of Dues.—In accordance with the resolution passed at the last Annual Meeting, the Secretary has endeavored to procure a definite statement from each member who was in naval or military service of the United States and Allies, and has credited, subject to the approval of the Executive Committee, an amount of dues covering the period of service, with a minimum of one year. The following have made statements and received credit (in the absence of definite instructions on the point, the Secretary has taken the date of the armistice as the termination of the period of remission):

J. W. Bailey.
J. P. Baumberger.
F. H. Benjamin.
L. L. Buchanan.
R. T. Cotton.
Howard Curran (Canadian).
D. M. DeLong.
E. L. Diven.
Jas. C. Evenden.
John R. Eyer.
Harry L. Fackler.
F. A. Fenton.
Theodore H. Frison.
Richard T. Garnett.
Edmund H. Gibson.
Maurice E. Hays.
Morgan Hebard.
Walter N. Hess.
J. D. Hood.
Neale F. Howard.
L. O. Jackson.
J. L. King.
H. H. Knight.
W. H. Larrimer.
C. E. Mickel.
Martin E. Mosely (British).
Philip A. Munz.
Geo. B. Newman.
J. Speed Rogers.
G. J. Spencer (Canadian).
E. H. Strickland (Canadian).
John N. Summers.
J. B. G. Tulloch (British).
D. L. Van Dine.
Chas. A. Weigel.
R. C. Williams, Jr.
Wm. C. Woods.

A total of 37 individuals, representing 49¼ years service. $98.50 in all has been remitted in dues.

There are a few more to hear from.

Regarding payment of dues, the members were in the following classes on December 22d:

Paid for 1919	425
Owing one year	55
Owing more than one year	68
New members not yet paid	36
Life members	11
Honorary Fellows	6
Total membership	601

Four life memberships have been taken since the last report: By E. D. Ball, G. C. Crampton, J. F. Illingworth and J. Bequaert.

Respectfully submitted,

J. M. Aldrich, *Secretary.*

December 22, 1919.

TREASURER'S REPORT.

December 17, 1919.

RECEIPTS.

Balance Dec. 23, 1918 (Annals, Mar., 1918, p. 60)	$1,173.99
Dues of Members	930.00
From Managing Editor of Annals	395.77
Interest on Current Account	16.60
Interest on Permanent Funds	28.27
One Life Membership in cash	50.00
Exchange	.06
Total	$2,594.69

DISBURSEMENTS.

Annals for 1918—March		$302.50
June		296.00
September		244.00
December		325.00
Engraving for Annals		53.17
Postage and envelopes, Annals		35.20
Clerical help, Annals		18.45
Stamps and stamped envelopes, Secretary		23.00
Printing, Secretary		20.58
Clerical help, Secretary		35.00
Telegrams, two, in arranging symposium		2.00
One War Savings Stamp		4.23
Balance, cash in Commercial Nat'l Bank, Washington	$1,211.40	
In Fowler Nat'l Bank, Lafayette, Ind	24.16	
		1,235.56
		$2,594.69

Note.—The one War Savings Stamp was purchased with $2.00 interest on Permanent Fund, plus $2.23 of the balance of $2.74 of Permanent Fund which was carried over uninvested at last report. The balance, 51 cents, of this uninvested item, is still carried in our bank balance above, as is also one Life Membership which belongs to the Permanent Fund, but was received so recently that the matter of its investment was left to the Executive Committee at the present meeting.

Condition of Permanent Funds.

On hand last report (Annals, March, p. 60)	$586.58
E. D. Ball, life membership	50.00
G. C. Crampton, life membership	50.00
J. F. Illingworth, life membership	50.00
J. Bequaert, life membership	50.00
One War Savings Stamp (see note under Disbursements)	4.23
Appreciation of 10 War Savings Stamps	1.20
Interest	28.87
Total	$820.88
Less interest transferred to current fund	26.87
Present balance	$794.01

SECURITIES HELD.

Bonds reported last year	$550.00
10 War Savings Stamps, present value	43.50
U. S. Bond, No. 9,938,349	50.00
U. S. Bond, No. 1,747,437	50.00
U. S. Bond, No. 14,145,890	50.00
Cash balance, carried in current fund	50.51
Total	$794.01

Respectfully submitted,

J. M. Aldrich, *Treasurer.*

Washington, Dec. 17, 1919.

REPORT OF THE MANAGING EDITOR.

It will very likely be taken for granted that in the publication of the Annals we have had to meet some of the difficulties and discouragements that seem to have troubled most of the enterprises of the year. It will not be necessary to detail them here but we trust that those who have been inconvenienced by delays or errors will accord the charity that is granted other delinquents. In spite of unfavorable conditions our subscription list has been well maintained, a number of back volumes have been sold and a number of authors have very generously assisted in the expense of providing illustrations for their papers.

Our expenses have been kept at the lowest point possible with due regard to creditable publication and we have been fortunate in continuing contracts for printing with but slight advances in certain details. However, a readjustment involving an advance to cover higher cost of paper will have to be met the coming year.

Receipts of the office have amounted to $422.70, of which $398.77 have been turned over to the Secretary-Treasurer, the balance being used for minor items of expense indicated in the following summary:

RECEIPTS.

Subscriptions	$259.00
Sale of back volumes	117.75
Reprints and engravings	45.95
Total	$422.70

DISBURSEMENTS.

Stamps and postal deposits	$ 17.43
Labor	2.50
Refund on double subscription	4.00
By balance paid to Treasurer	398.77
Total	$422.70

I believe we may feel proud of the character of articles published during the year and there is in hand a supply of excellent material for the coming year. If we are to enlarge the Annals to take care of the desirable papers offered we will need a larger income and this must be sought in a larger membership, an advance in membership and sub-

scription rates or in a larger sale of back volumes of which we have still a fair reserve. It is certainly desirable to maintain as wide a circulation as possible and while the price of the ANNALS is low compared with other journals it may be best to attempt to carry it forward another year or two, at least, at the old rates. A very decided help would be given if members would fill out their sets of back volumes or assist in placing sets in libraries which have not a complete series.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

The Executive Committee reported that they had made the following appointments:

Thomas Say Foundation, three years: NATHAN BANKS and A. D. MACGILLIVRAY; two years, C. GORDON HEWITT and WM. T. DAVIS.

Editorial Board: S. A. FORBES, A. D. HOPKINS and A. L. LOVETT.

The Auditing Committee reported as follows, and on motion the report was accepted:

The Auditing Committee have examined the books of the Editor of the ANNALS of the Entomological Society of America and the Treasurer of the Thomas Say Foundation and have found the same correct.

S. HADWEN,
C. H. TURNER,
J. L. KING,
Committee.

In the absence of the Secretary-Treasurer, his books were audited by a special committee of the Society in Washington, D. C., who made the following report, which was accepted:

Your Committee has examined the records and vouchers reported by the Secretary-Treasurer, J. M. Aldrich, and find the same to be correct and properly kept.

H. S. BARBER,
A. N. CAUDELL,
Committee.

The Committee on Entomology in the National Museum presented a report, and following a discussion the report was accepted with the adoption of the following motion:

Moved, That this Committee be empowered to combine its report with that of the Museum Committee of the American Association of Economic Entomologists; that an abbreviated report based on the two separate reports be printed for publicity purposes, half of the expense to be borne by the Entomological Society of America; that the National Research Council be informed of the needs of the National Museum and their consideration and support be urged.

The combined report is printed at the end of these minutes.

The Nominating Committee submitted the following nominations:

President—L. O. Howard.

First Vice-President—F. E. Lutz.

Second Vice-President—Edith M. Patch.

Secretary-Treasurer—J. M. Aldrich.

Additional Members Executive Committee—W. S. Marshall, G. A. Dean, J. W. Folsom, G. W. Herrick.

Committee on Nomenclature—E. P. Felt, T. D. A. Cockerell, Nathan Banks.

Committee on Entomology in the National Museum—C. W. Johnson, Herbert Osborn, Wm. Barnes, W. M. Wheeler, J. G. Needham.

On motion the Secretary was instructed to cast the ballot of the Society for the candidates nominated. This being done, they were declared duly elected.

FOURTH SESSION.

8:00 p. m. The Society was called to order by President Needham, who introduced Dr. Wm. J. Holland, Director of the Carnegie Institute. Doctor Holland gave the Annual Address upon the subject "The Evolution of Entomological Science in North America." The address is printed in this number of the Annals.

The Society then adjourned.

C. L. Metcalf.
Secretary pro tem.

ENTOMOLOGY IN THE UNITED STATES NATIONAL MUSEUM

The day has long passed when American scientific activities can be restricted to a narrow field. Whether we regard the economic needs or the intellectual development, we find ourselves compelled to consider the whole range of science, limited only by our resources and the powers of the human mind. In the field of Entomology this involves, among other things, access to adequate collections of insects, including not only those found in North America, but the species of the whole world. The leading European countries have long appreciated such needs, and have built up collections to which Americans have to make pilgrimages when engaged in comprehensive studies of insect groups. There is no reason why we should not possess facilities for work at least equal to those of any other country. We have the greatest material resources of any nation at the present time, and certainly are not lacking in the ability to carry on the work.

The species of insects are far more numerous than those of any other group of animals; in fact the described forms exceed those of all other groups combined. Very many of them are of supreme importance and interest to man, as destroyers of our crops, carriers of the germs of disease, enemies of other injurious insects, or sources of some of our most important economic products. All know the value of the silkworm and the honey bee, but few realize the services of the best of parasitic insects, which keep down the enemies of our crops, and without which agriculture would be impossible. All are aware that numerous insects are injurious to plants, but comparatively few know that many of the most harmful of these have been introduced from abroad. The greatest danger to our crops, or even to our health, may arise from insects accidentally brought from foreign countries through the operations of commerce. The San Jose scale, dangerous enemy of many fruits, came from Asia; the cottony cushion scale, which once threatened the extinction of the orange industry in California, came from Australia. The gypsy moth, which has cost this country hundreds of thousands of dollars to fight, is European. The cotton boll weevil, even more to be dreaded, invaded the United States from Mexico and Central America. For urgent practical reasons, therefore, as well as in order to complete and organize our knowledge, we need to know the insects of all countries, and to have them represented in at least one American collection.

This obvious requirement of a great collection representing the insects of all lands, cannot be met without Congressional aid. The National Museum, under present conditions, or better, limitations, cannot possibly adopt an adequate policy of entomological development. The two prime obstacles are lack of sufficient curators and lack of space. The present force of curators, even with the aid afforded by the members of the Bureau of Entomology, cannot arrange and classify the collections already on hand, incomplete as these are. Some of the men work overtime and on holidays, while help is sometimes obtained from those not officially connected with the Museum. But all these

activities lamentably fail to meet the whole need. The Museum should have enough expert curators to keep classified and in order, the available material in every group of insects, and to furnish identifications and other aid to economic entomologists and other workers in every State. Should a sufficient curatorial force be supplied, however, it would be helpless in the present crowded condition of the department. There is hardly room to move around, and almost no space for new cabinets. The only way out seems to be through the erection of a new building of suitable size; fireproof, but not necessarily of any great architectural pretensions.

Granting the building and the curators, with suitable rules and arrangements to ensure the proper care of all the collections, what more should be demanded? Undoubtedly collectors and students would present or bequeath their materials on a scale previously unheard of, because of the great services they had received from the Museum and their confidence in it as a repository of types and other priceless specimens. This, however, would not suffice. Funds should be available for explorations within the United States and abroad, to discover insects hitherto unknown or unrepresented in the Museum.

With curators, building, and adequate collections, we are still confronted by another urgent need. The results of the work done must be made available to scientific men in every part of the country. This can only be brought about through the creation of adequate publishing facilities, insuring the reasonably prompt appearance of each work completed. At the present time authors hesitate to undertake large monographs not knowing when they will see the light of publicity, nor indeed whether they will ever do so.

Prepared by the Committees to investigate conditions and needs of the United States National Museum.

Entomological Society of America:

T. D. A. Cockerell,
Professor of Zoology, University of Colorado.

Herbert Osborn,
Research Professor, Department of Zoology, Ohio State University.

Wm. Barnes,
Surgeon, Decatur, Illinois.

Wm. M. Wheeler,
Dean Bussey Institute, Harvard University.

J. G. Needham,
Head, Department of Entomology, Cornell University.

American Association Economic Entomologists:

John J. Davis,
In charge, Japanese Beetle Project, New Jersey State Department of Agriculture.

Vernon L. Kellogg,
Secretary, National Research Council.

E. P. Felt,
State Entomologist, New York.

Herbert Osborn,
Research Professor, Department of Zoology and Entomology, Ohio State University.

E. D. Ball,
State Entomologist, Iowa.

Committee.

(Approved and adopted at St. Louis, Missouri, by the Entomological Society of America, on December 30, 1919, and by the American Association of Economic Entomologists, on January 2, 1920.)

NOTICE TO MEMBERS AND CONTRIBUTORS.

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5 x 7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The Managing Editor is provided with the most recent address of all paid-up members on record in the Secretary's office for mailing the numbers of the Annals and members failing to receive their numbers should present their complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate.

The regular annual subscription price for the ANNALS is in the United States, Cuba, Porto Rico, Hawaii and Mexico, $3.00; Canada, $3.50; other countries, $4.00. Checks, drafts or money orders should be drawn payable to ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA, and addressed to HERBERT OSBORN, State University, Columbus, Ohio, U. S. A.

Requests for information as to membership and the annual dues of members should be sent to the Secretary-Treasurer, J. M. ALDRICH, National Museum, Washington, D. C.

Communications relating to the ANNALS, and all orders for separate copies or reprints should be addressed to

HERBERT OSBORN, Managing Editor,
ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA,
State University, Columbus, Ohio.

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ANNALS

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The Entomological Society of America

Founded 1906.

OFFICERS 1920.

President

L. O. Howard . . . . Washington, D. C.

First Vice-President

F. E. Lutz . . . . New York, N. Y.

Second Vice-President

Edith M. Patch . . . . Orono, Maine

Managing Editor Annals

Herbert Osborn . . . . Columbus, Ohio

Secretary-Treasurer

J. M. Aldrich . . . National Museum, Washington, D. C.

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Wm. S. Marshall, J. W. Folsom,
G. A. Dean, G. W. Herrick.

Committee on Nomenclature

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Thomas Say Foundation

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Committee on National Museum

C. W. Johnson, Chairman,
Herbert Osborn, Wm. Barnes, Wm. M. Wheeler,
James G. Needham.

ANNALS

OF

The Entomological Society of America

Volume XIII JUNE, 1920 Number 2

Symposium on "The Life Cycle in Insects."*

1. APTERYGOTA.

J. W. Folsom.
University of Illinois.

In a discussion of the life cycles of insects it is logical to begin with Apterygota because their type of life cycle is the simplest, as it involves no metamorphosis.

Though Thysanura and Collembola undergo no changes that are sufficiently striking to constitute a metamorphosis, they nevertheless exhibit in their postembryonic development various minor changes of structure and coloration.

For example, *Lepisma saccharina* at hatching is whitish; is a slender creature, on account of its narrow thoracic segments; and does not have as yet the characteristic styli of the eighth and ninth abdominal segments. The antennæ have only 22 segments, though they later develop some 60 or 70 subsegments; and the lateral cerci have at first only 10 segments. Lepisma, as it emerges from the egg, has no scales. Even the first molt, which occurs seven days from the time of hatching, brings no change in these respects. (Heymons.)

In Collembola, at hatching, the head is large in proportion to the body—much as in a grasshopper. As the individual grows there are changes in the relative lengths of the segments of the body and of those of the appendages. Thus, in *Tomocerus vulgaris*, comparing small and large individuals:

*Presented at the St. Louis meeting, December, 1919.

	SMALL	LARGE
Ratio, third to fourth antennal segment	1 : 1	2.9 : 1
Ratio, third to fourth abdominal segment	1 : 1	1.5 : 1
Number of intermediate teeth of mucro	1	8
Number of teeth of unguis	1	4 to 6

Intergradations in these respects occur in individuals intermediate between these two extremes. This variation, occurring during the growth of a single individual, is so extensive that one who studied only one of the youngest and one of the oldest specimens might easily mistake them for two distinct species. (Schäffer.)

In a few Collembola the number of antennal segments increases after birth. *Heteromurus*, for example, is born with four, but develops five by the division of the basal segment into two. *Orchesella* has at first four, and finally six, by the division of the two proximal segments. The fourth antennal segment may become subsegmented after birth, as in *Sminthurus* and *Heteromurus;* and numerous subsegments develop in the third and fourth segments in *Tomocerus.*

The postembryonic changes in coloration in Collembola are often striking. Collembola at hatching are usually white (sometimes yellow), except for the black ocular pigment, though most of them acquire pigments and color patterns later. *Anurida maritima* at first white, becomes dark blue. Species of *Sira* at birth lack their characteristic color patterns. *Calistella*, yellow at hatching, gradually develops its color pattern with each molt, and completes its pattern with the seventh molt. (Skorikow.)

Our knowledge in regard to seasonal histories in Apterygota is fragmentary. *Campodea fragilis* survives the winter and has been kept alive several months in captivity. *Machilis maritima* lives longer than one year, is sexually mature in spring, and does not molt in winter but molts at frequent intervals during the rest of the year. *Lepisma saccharina* is like *Machilis* in these respects. (Oudemans.)

Among Collembola, *Achorutes armatus* in Massachusetts has three generations during the year, and possibly four, which mature at intervals of about six weeks. *Achorutes packardi* in Massachusetts has two broods annually, the eggs being laid late in April and hatching in about one month. This species exhibits seasonal dimorphism; its variety *dentatus* laying eggs that produce *packardi.*

The following data were sent to me from Arnprior, Ontario, by Mr. Charles Macnamara, an exceptionally keen and thorough observer:

"Around here *Achorutes socialis* (the 'snow-flea') oviposits in spring, and the mature individuals have disappeared completely by June 1st. Well-grown individuals begin to appear again in September and October, but the very largest usually (not always) are to be found only in April and May. Apparently they grow all winter under the snow. As an exception though, I found some 2 mm. individuals (the maximum size) in late October, on a white birch.

"Eggs of *Achorutes socialis* hatch in 11 to 14 days, and in 9 to 10 weeks the young are .3 mm. to .5 mm. long, and fairly well pigmented. Another spring layer is *Onychiurus fimetarius;* eggs of which laid May 2, hatched May 22, period, 20 days.

"In my vials in the house, *Achorutes humi* and *Neanura muscorum* both oviposited in the early winter. Eggs of *A. humi* laid November 15, hatched December 7, period, 22 days. Those of *N. muscorum* laid December 4, hatched January 8, period 35 days. Under natural conditions outside, however, I doubt if the eggs of these two species would have hatched until spring.

"Specimens collected as well-grown adults survive in captivity for very various periods. *Sminthurus* and *Papirius* in my hands are always very short-lived—a few weeks at most. *Isotoma* may live for a couple of months, but the most resistant to captivity are *Achorutes socialis*, 5 to 6 months; *A. packardi*, 7 months; and *Xenylla maritima*, 12½ months. In estimating the length of life to these periods should be added the age when captured, and of course that is unknown to me.

"*Achorutes socialis* continues to grow long after it is sexually mature, and keeps casting its skin as long as it lives."

This is true of Collembola as a rule, which molt after growth has ceased. The total number of molts has not been ascertained in the case of any collembolan. *Tomocerus plumbeus* molts throughout the year at intervals of two to three weeks. (Sommer.) In *Tomocerus flavescens americanus* the intervals between successive molts increase with the age of the individual. Thus the youngest specimens molt every two days, and old individuals every six to eight days.

It remains to summarize the significance of these facts as follows: Apterygota at hatching are not structurally finished, or complete; but undergo further development in respect to various details of structure.

The postembryonic development of pigmentation in Collembola is (to judge from observations made on several genera) the direct result of exposure to sunlight, and may be prevented

by keeping the insect in darkness, as in the case of *Anurida*. On the other hand, the embryo *Anurida* develops pigment prematurely if the egg is exposed to sunlight.

The colors and color patterns of Collembola are not known to have any adaptive significance. Many Collembola resemble their environment in color, to be sure, but there is no evidence that this resemblance is of any advantage to the organism.

The most conspicuous fact in regard to the seasonal history of Collembola is their tolerance of low temperatures. Many species are active in winter when most other insects are not. Some species grow and molt during winter, and lay eggs at low temperatures. Thus one species was seen to lay eggs at 0° C. The temperature-range of activity is lower than that of other insects. Thysanura, on the contrary, are far less tolerant of cold. Some of them hibernate but do not grow, molt, or lay eggs in winter. Thysanura are not known in the Arctic region; though the arctic and subarctic Collembola number some seventy species.

Apterygota molt at frequent intervals throughout life; are long-lived and have therefore many molts; the number being indefinite.

In Collembola, ecdysis is something more than a provision for growth; occurring as it does after growth has ceased; and being, in part at least, an excretory process. With each molt the inner half of the epithelium of the mid-intestine is cast off and discharged from the food canal, and with it are expelled pseudocrystals of sodium urate, which have previously accumulated in the epithelial cells. This process is correlated with the absence of Malpighian tubes in Collembola.

Apterygota best illustrate simplicity of the life cycle. They are relatively simple in structure, development and habits, in correlation with their environment, which is relatively simple and remains constant. The functions of growth and reproduction are not sharply separated as they are in Pterygota. Apterygota, being primitively wingless insects, show none of the specializations associated with the presence of wings; such as a firm integument, differentiation and consolidation of the thoracic segments, and the development of various thoracic sclerites in relation to muscles of locomotion. Neither are there found such extensive modifications of the abdomen in relation to reproduction, as occur in pterygote insects.

Thysanura and Collembola exhibit certain specializations of structure and function, but these are of minor importance—Apterygota being essentially the most generalized group of insects. They exemplify a life cycle without metamorphosis and are, so to speak, larviform, but with the power of reproduction.

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2. THE LIFE CYCLE OF THE ORTHOPTEROID ORDERS.

E. M. Walker,
University of Toronto, Toronto, Ont.

The Orthopteroid insects (sens. lat.) include all such forms as have mouth-parts of the mandibulate type and undergo a gradual or "incomplete" metamorphosis.

As in other orders of insects, the extent to which the immature stages ("nymphs") diverge from the adult in form and structure is more or less proportional to the differences in environment and habits. Accordingly they may be divided into two groups, (1) those which are terrestrial throughout life, and (2) those in which the early stages are aquatic.

Group 1 includes the Blattoidea, Mantoidea, Isoptera, Zoraptera, Grylloblattoidea, Phasmoidea, Orthoptera, Dermaptera, Embiidina, Corrodentia and Mallophaga. Group 2 includes the Plecoptera, Ephemerida and Odonata.

In Group 1 the habitat and feeding habits are not materially altered during the life cycle, so that the same structural adaptations are present throughout life, and the metamorphosis is entirely gradual, except at the last moult, when the wings, if present, and the genitalia undergo more or less marked changes. There is, however, little or no histolysis of larval structures. The number of moults is comparatively small, so far as known, being usually four to six, but sometimes reduced to two or increased to seven or eight. A pronymphal stage is sometimes present. The nymphs resemble the adults except in size, details of proportion, chætotaxy, scuplturing and sometimes colour-pattern, and in the thinner cuticle. The number of antennal and occasionally tarsal joints sometimes increases with growth, and the ocelli, when present, may not appear until the last moult. The wings, when present, appear at an early stage,

usually the third or sometimes the second moult. Primitively they appear as caudo-lateral extensions of the meso- and metanota, from which they become separated at a later stage by a suture and a more constricted base.

The leading features in the life cycles of the orders of Group 1, so far as known, may be summarized as follows:

Blattoidea. Mostly nocturnal, hiding by day, with a tendency to be gregarious: feeding chiefly upon animal and vegetable refuse; eggs (16–50) arranged in two series in a horny ootheca, formed in the uterus, and carried for a time in the genital orifice; dropped in protected places without attachment; period of growth variable, 4 or 5 months to several years, but usually one brood annually; number of moults variable, generally 5–7. Hibernation in egg or nymph state. The adult males of some species differ considerably in form from the nymphs and the adult females. Styli of female disappearing at last moult, usually persistent in the male.

Mantoidea. Diurnal, solitary, living on foliage or on the ground, predaceous on other insects; eggs arranged in several series in a membranous or vesicular ootheca formed at the exit of the genital passage and attached to other objects, the number deposited varying enormously in different species (20–1000); incubation period varying according to season, a few weeks (summer) to 10 months (winter); hatching as a pronymph; number of moults 7 or 8 (Mantis); usually one brood; hibernation in egg or nymphal stages. Styli as in Blattoidea.

Isoptera. Cryptozoic, living in communities, often of many thousands of individuals, which are polymorphic, there being in addition to the fertile adults and nymphs, sterile wingless castes of one or two types (soldiers and workers) and sometimes reserve fertile individuals (substitution royalties), which in other respects remain immature. Reproductive activity limited to few individuals, the kings and queens, (and the substitution royalties), the queens of enormous fecundity, and having the final or reproductive stage greatly prolonged (sometimes several years). Superfluous winged adults leave the colony, flying in swarms, but soon lose their wings. Food largely of wood, proctodæal excreta, saliva and organic refuse, varying in composition according to caste. There are generally no special modifications in the nymphs, except the lack of eyes and

the very thin cuticle, associated with the cryptozoic life. The number of antennal segments increases with development. Large prothoracic expansions are present in the nymphs of some species.

A few species of Isoptera are inquilines in the nests of other species of the same order.

Zoraptera. Inquilines in the nests of certain Isoptera; life cycle unknown.

Grylloblattoidea. The single species is alpine, living under stones and on snow; carnivorous (has been fed on ant pupæ); metamorphosis practically confined to the genitalia; styli present except in adult female. Hibernating as nymph or adult.

Phasmoidea. Phytophagous, generally on trees and bushes; voracious and reaching in some species an enormous size. Eggs few (12–100), each in a separate seed-like capsule, dropped at random. Incubation period sometimes extending over two years. Period of growth variable, 6 weeks to 16 months; number of moults few, variable, two or three in known cases. Nymphs usually not differing much from adults.

Orthoptera. Diurnal or nocturnal; arboreal to subterranean; phytophagous or partly carnivorous. Eggs moderately numerous, buried in plant tissues or in the ground by an ovipositor (except in subterranean forms); in the Acrididæ imbedded in a vesicular ootheca. Incubation period generally over winter in temperate climates, comparatively few species hibernating as nymphs or adults. Generally one brood, moults 4 to 6. An inversion of the wings takes place at about the fourth moult, the hind wings overlapping the front, until the final ecdysis, when the normal position is restored and the hind wings folded. Otherwise the nymphs are usually lacking in special modifications, though the color pattern is sometimes distinctive.

Dermaptera. Carnivorous and phytophagous; eggs dropped at random but sometimes picked up afterwards by female and carried to places of safety; in *Forficula auricularia* deposited in early spring; period of growth in this species about 5 weeks; moults 3 or 4. One or two broods, hibernating at various stages. Special form changes: Increase in the number of antennal segments; cerci of a few primitive genera segmented in the nymphal stages.

The aberrant African genus *Hemimerus*, parasitic on rodents, is viviparous.

Embiidina. Living under damp stones and wood on the ground, nests of ants or termites, in small colonies but not forming societies; the nymphs constructing passages lined with a silk-like secretion from glands in the maxillæ; partly carnivorous, partly phytophagous; nymphs very similar to adults. Tropical or sub-tropical.

Corrodentia. On bark, under logs, old books, etc., feeding on animal and vegetable refuse, mouldy substances, etc. Eggs laid in patches or clusters under bark, or in other protected places, covered with a web; incubation period generally during winter in temperate climates. Period of growth probably short, there being sometimes two or perhaps three broods. Number of moults said to be four in Psocus. Nymphs resembling adults but without ocelli, which are present in the adults of winged species.

Mallophaga. Epizoic on birds and mammals, feeding on feathers, epidermal debris, etc.; eggs glued singly to hairs or feathers in the area inhabited by the insect, sometimes localized in groups common to many individuals. Incubation period not known definitely for any species, probably long; number of moults also unknown, apparently few. Length of life probably several months in most cases.

In Group 2 the nymphs, or *naiads*, differ from the adults more widely than in group 1 in correlation with the greater difference in environment. The period of growth is usually longer, being frequently three years, and the number of moults greater. Length of life cycle is to some extent proportional to size attained.

Plecoptera. The stone-flies show least divergence between larval and adult structure. The adults are feeble insects of secretive habits, serving only for the function of reproduction. Eggs small, carried by the female for a time in a mass at the genital orifice, and finally dropped freely into the water. Naiads inhabit well aerated water, clinging to undersides of stones, to which habitat they are adapted by the possession of filamentous tracheal gills, chiefly thoracic, and by their flattened form and legs, the latter fringed with swimming hairs. Food of naiads smaller aquatic animals. Length of life probably one to three years; number of moults not known for any species, probably very variable. Adults appear usually early, sometimes emerging on ice and snow, the order having on the whole a remarkable power of withstanding cold.

Ephemerida. Naiads phytophagous, diverging from the adults more widely than in the Plecoptera and showing a wider range of adaptation in form and structure. Life cycle varying from a few weeks to three years, aquatic except in the last two stages (subimago and imago), both of which have functional wings but live only a few hours to a few days and take no food. Number of moults large, apparently sometimes 30 or more. The most marked changes acquired on reaching the subimago stage are the enlargement of the compound eyes, the development of ocelli, reduction of antennæ and mouth-parts, development of wings and genitalia, loss of the tracheal gills, elongation of the cerci, with loss of their setæ, besides more or less marked changes in general form. Adult phase generally appearing in early summer, usually crepuscular or nocturnal and serving only for the mating function. Eggs deposited in large numbers, without capsule, sometimes attached to other objects.

Odonata. The habitats and corresponding modifications of the naiads of this group are similar to those of the preceding, but their habits are wholly predaceous. Developmental period varying from a few months to three years or more, the number of moults variable, even in the same species, 11 to 15 in known cases. A pronymphal stage is present.

The principal adaptations of the naiad are: Modification of the labium as a prehensile arm; (2) special respiratory organs, viz., three leaf-like terminal tracheal gills in the suborder Zygoptera, which also serve as fins, or numerous gills in the rectal chamber in the suborder Anisoptera. Wing pads of naiads reversed in position as in Orthoptera. Adults comparatively long-lived, active, predaceous, diurnal, showing the following changes of structure at the final moult in relation to the change of habits: Enormous enlargement of compound eyes and development of ocelli; shortening and change of form of labium, the larval structure being absorbed by histolysis; modification of thoracic segments and legs in adaptation to habits of flight and perching; elongation of abdomen and development of genitalia. There is a short quiescent stage, equivalent to a pupa, in which no food is taken. Oviposition endophytic or exophytic, the eggs in the latter case being sometimes scattered, sometimes enclosed in a gelatinous envelope, or attached to objects in water; generally several hundred deposited.

3. THE LIFE CYCLE IN HEMIPTERA
(Excl. Aphids and Coccids.)

By E. D. Ball.

The life history of any insect if carefully and conscientiously traced, will show many and striking adaptations. These in the aggregate will be found to display a marvelous adjustment to and harmony with the environment. The life cycle may be long or short, occurring early or late, the generation one or more and the winter passed as egg, nymph or adult, according as these variations adapt the insect to its individual niche in the scheme of things.

In the main these adaptations are not, however, mere adjustments to a temporary excess of heat or cold, moisture or dryness, but rather are deep-seated and fixed modifications brought about through reaction to seasons unnumbered whose means, at least within the limits of the present geological period, are constants. Such adaptations as these are not to be overthrown by the influence of an early season or a late one, a heavy rainfall, or even an arid condition. They are merely modified in detail, but these modifications only serve to emphasize the fixity of the underlying principle. The man who wrote "The number of generations a year will vary in different parts of the country according to the various climates and is likely to fluctuate from year to year in accordance with seasonal variations" was so impressed with trivial details that he entirely missed the great concept of nature's plan whereby each and every species exists as a species primarily because it has through the ages become differentiated and adapted to its humble place in the structure of life. His concept of nature is that of the thistledown blown by the wind while the reality is the majestic elm bending and waving in every passing breeze but which in the end remains firm and upright.

Commencing with the Cicadidæ as probably the lowest type of the field assigned, we find a marked uniformity in their life history in that all the species pass the winter as nymphs and all have an under-ground habitat, coming out as adults with marked uniformity in the middle of the summer. Beyond that,

little is known except for one species in which the life cycle requires 17 years and a variety in which this number is reduced to 13. Popular opinion credits the other species with two-year cycles. According to W. T. Davis this originated with Jæger in the "Life of North American Insects" published in 1854 and he credits the information to Pontedera. Whether Pontedera's statement was the result of experiment or only a guess has apparently never been tested. Absolute fixity of the 17 and 13 year cycles is, however, one of the marvels of nature and should be an everlasting refutation of any suggestion that insect activity is subject to fluctuation like the ever changing thistledown.

The Cercopidæ or Frog-hoppers show a marvelous adaptation in their froth making habit and they have apparently depended largely upon this rather than other modifications for their protection. All of our local species have a single annual generation and all but one pass the winter in the egg stage. The variations in this single generation will be discussed under that head in the next family.

The Membracidæ or tree-hoppers are celebrated for the wonderful variety and complexity of their adaptations to their food plants. When it comes to the life cycle on which most of these adaptations are based, it is found to be fundamentally very simple. 90 per cent or more of our species have a single annual generation and more than 90 per cent pass the winter in the egg stage. The tree hoppers of the genus *Telamona*, for example, feed very largely on the sap of the trees and mainly on the tender growing twigs. They find optimum conditions for such feeding only during the comparatively short period in which the tree is making its growth. They also must find a location and deposit their eggs while the wood is still soft and tender; otherwise they will be unable to penetrate to a sufficient depth to protect the eggs from predacious and parasitic insects. The result is that we find that they, with a possible exception, pass the winter in the egg stage and have a single annual generation. The overwintering eggs in the twigs hatch almost with the first growth in May. The nymphs mature in June. The adults lay eggs in July and August and the cycle is finished.

In the case of *Ceresa bubalis* (the Buffalo tree-hopper) and its vegetation-feeding allies the need of haste is not so great as their food plants, Composits, Legumes and others, grow all

summer, so we find the nymphal period both longer and later and the adults extending into the fall.

A striking adaptation to a special period in a plant's growth, is shown in the life cycle of *Micrutalis calva*, the little shining black seed-like tree-hopper. The nymphs are found between the branches of the blossom head of the Ironweed, *Vernonia*. This purple flower appears only in the fall, so that the single generation of nymphs comes on over 70 days later than its relative that lives in the tree.

Later appearing nymphs usually come from overwintering adults that feed for some time before laying eggs. The complete life cycle of this species is not known. What we do know corresponds with the life cycle of *Publilia* in which we know that the adults hibernate and that there is a single generation on thistles, sunflowers and other late growing *Compositæ*.

The writer has never studied a double brooded tree hopper. Funkhouser, a careful student of the family, has, however, published the details of his observations on *Vanduzea arcuata* which lives on the Black Locust. From the observed facts the writer has been able to construct a complete life history chart showing two generations, with the winter passed in the egg stage.

It is to be regretted that after completing this fine series of observations that Prof. Funkhouser allowed himself to be led astray by the example of that all-too-numerous band of dilettante and superficial workers in Entomology whose chief indoor sport has been the working out of life histories by the mathematical route. The only thing necessary for these scientific wizards is to ascertain the time that it takes an egg to hatch and a nymph to develop, add the two, and divide the length of the season by this number. The quotient is *not* the number of generations nor even the number of *possible* generations of the insect that they fondly imagine it to be, but a mathematical fiasco and a scientific absurdity, patent to anyone who will give the matter serious thought.

If the time of the stages used was a fair average of the season our short-cut investigator will probably find three or four broods. If the minimum time found in the midsummer period alone is used and our rapid calculator is optimistic about the spring and fall weather, as he is usually, then at least 5 or 6 generations will be proclaimed. If our mathematical prodigy would only take the trouble to investigate the literature (which

he will not) he would find that no one has ever carried a single species of the higher Homoptera through as many as three complete generations in a season.

There are two fundamental fallacies embodied in all calculations of this kind. The first and most important being that Nature is trying to see how many generations she can produce annually. She is not—in Hemiptera or Orthoptera at least—but rather trying to see how perfectly she can adjust the distribution of the one or two generations to the optimum conditions for development in the variable seasons. The tree hopper might have three generations as far as the time factor was concerned but it can have tender twigs for only one and one it consequently has. The little black *calva* might have three and our mathematical optimist would say four generations but it could not have the rich food destined for the forming seeds in more than one and so it is content with one.

The second common fallacy is that the time from egg to adult is the measure of a generation—it is instead only about half of the period. In the Hemiptera the adult emerges with eggs undeveloped and they must feed and develop them before egg laying begins. Somewhere in this period mating takes place. Funkhouser shows mating 10 or 15 days after the adults appear in *Vanduzea.* Johnson states that the grape leafhopper fed 10 days before mating, Childs shows a longer period for the rose leafhopper, while Fenton and Hartzell show a still longer period for the potato leafhopper before egg laying began. In some cases the mating appears to be near the beginning and in other cases near the end of the period, but in all cases it must of course precede egg laying. The total time therefore between adult emergence and egg laying appears to be from 10 to 25 days.

Hemipterous insects rarely if ever lay all their eggs at one time. Instead the Homoptera as a rule lay a few at a time through long periods. Hodgkiss found *Stictocephala* laying as many as 250 eggs through a two-month period. Johnson found the grape leafhopper laying 115–140 eggs through a 70-day period. Ball found the beet leafhopper laying eggs for two and a half months. Fenton and Hartzell found the potato leafhopper laying eggs for 50 days. In all life history studies made, this period has been shown to be longer than the time required from egg to adult and often two or more times as long. This period,

which must be considered as part of the time required for a complete cycle, will amount to from 30 to 70 or more days.

The total time required for the development of a complete generation of a Hemipterous insect will then be made up of the following factors and be somewhere within the limits suggested:

	Min.	Ave.	Max.
Development of eggs (including mating time)	10	17	25
Period of egg deposition	30	50	75
Egg Stage	10	15	35
Nymph stage	12	30	55
	62	112	190

This tabulation, which is of course merely suggestive, indicates that the minimum time necessary to mature a complete brood is over two months, the average time three and two-thirds months, and that in some cases it requires over six months for the process.

With these facts in mind we may return to Professor Funkhouser's too ready acceptance of the facilities of the mathematical prognosticator and note that the first two of his proposed generations correspond with the beginning and maximum of the first generation according to his own statements and that the remaining two belong in the same way to the second. He found only two mating periods and these correctly.

Wildermuth working in Tempe, Arizona, gave careful and accurate figures on the beginnings of each stage in the life cycle of *Stictocephala festina* and especially increased our knowledge of the effect of temperature upon the rate of development of eggs and nymphs, showing an average variation in egg development from 14 to 35 days and of nymphs for 32 to 68 days. He, however, was led into the common error and after giving detailed figures enabling the writer to chart two definite broods he "calculated" that there were four broods. He did not give figures that would enable one to close up the posterior extensions of the stages with accuracy but the ordinary extension is amply sufficient to explain the presence of all stages late in the season which misled him into the four brood fallacy. The chart is also interesting in showing the wide variations in the time of appearance of insect life in the arid southwest as compared to that in New York. This is especially noticeable when it is remembered that this is a species with an adult hibernation which under

ordinary circumstances would tend to throw the first generation later than the one that wintered in the egg stage.

The writer's experience in the arid region and especially in the Imperial Valley indicates that this early starting is an almost uniform adaptation. Insects develop abnormally early in the spring before ordinary temperatures are reached and their life cycle is practically completed before the drying up of the vegetation by the excessive heat of the fall so that only those stages that are developed to resist adverse conditions remain in any numbers. This will be brought out again in the case of the grape leafhopper.

The CICADELLIDÆ or leafhoppers, have more economic species and have received more study than any other family in the group. On the other hand the FULGORIDÆ, called lantern flies, or more commonly leafhoppers have probably received less attention. Both groups of these leafhoppers appear to have about the same variation in their life cycles and will be treated together. These leafhoppers feed on all types of vegetation, trees, shrubs, perennials, biennials, and annuals, under every condition of humidity, moisture, and temperature, and yet the writer has never been able to find a single example in which it could be demonstrated that more than two generations a year occurred nor on the other hand one in which there was less than one generation per season. This is a very limited range and yet, in almost every case investigated, a definite and sufficient reason could be found for the limitation in generations and that reason was almost invariably its adaptation to some period in the growth of its food plant.

The leafhoppers with a single annual generation may be roughly divided into three groups, depending upon whether they pass the winter as eggs, nymphs or adults. In general passing the winter in the egg stage will result in the earliest development in the spring, and in this class we find *Empoasca unicolor*, the real apple leafhopper. This species has been worked out by Lathrop in New York, Brittain, in Nova Scotia, and Fenton in Iowa, and all of them find an early nymphal period in May and June, with adults from that time on throughout the season, egg laying occurring late and these eggs going over winter. This, as explained previously, is the adaptation to the short period of growth of the mature apple tree and is a general type of adapta-

tion found in a large number of tree-infesting leafhoppers such as those found in the family *Bythoscopidæ.*

But a small percentage of the leafhoppers winter in the nymphal stage and when they do it is usually in response to some peculiar adaptation. *Dorycephalus platyrhynchus,* is a remarkable shovel-nosed leafhopper so wonderfully fitted to the stem of the *Elymus* (wild rye), that it is even said to show the rust spots so well that the species of rust can be determined. This species shows an equally remarkable adaptation in its life history. The eggs which are laid through a long period of time, hatch out at the time the flowers appear, and the little alligator-like hoppers waddle their way up the stalk to the head and come to rest flattened out beneath the glumes where they remain and suck out the nutrition intended for the developing seeds. When the seeds mature they pass to the base of the plant and feed on the green sprouts until winter. In the spring they come out and feed again until May when they change to adults, ten or eleven months from the time they left the egg. It would take a mathematician of some ability to figure many generations in a season of this species and it would take a mind of equal ingenuity to devise a more interesting adaptation.

In the old group *Tettigonidæ* the great majority of the species pass the winter in the adult stage and have a single annual generation. *Oncometopia lateralis* is a typical example of this group. In this we see the adults mating and beginning laying eggs in May, continuing until the end of July. The first eggs develop into adults some time before the last of the overwintering brood of adults disappear so that we have adults the year round and nymphs coming on through a period of three or even four or more months. The writer studied this species in Colorado and there the adults that develop, whether early or late, do not become sexually mature until the winter has been passed. The continuous occurrence through such a long period of time has frequently led the mathematical investigator astray. Sanderson working in Texas suggested a possible five generations, while Gibson working in Arizona, with what was probably a two brooded species, announced six.

Turning to the two brooded species of leafhoppers the life history of *Empoa rosæ,* the rose leafhopper, was carefully worked out by Childs in Oregon and shows a beautiful adaptation to the long and even temperature conditions during the growing season

of that region. Starting as early as the first leaves appear this species has a generation on rose the adults of which fly to the apple, producing there a second brood which in turn flies back to the rose to deposit eggs to pass the winter.

In sharp contrast with this extended life history period the potato leafhopper *Empoasco mali* as worked out by Lathrop in New York and Fenton and Hartzell in Iowa, shows a very restricted developmental period. The adults hibernate and as usual with such species appear late in the spring, feed on weeds through May, and fly to the potatoes in June. This year they appeared suddenly on potato June 6th, where they laid eggs for nearly two months. The first generation was produced on the early potatoes but the adults did not lay eggs there as they appeared. Instead they waited until after the summer migration which was mostly to the late potatoes and deposited their eggs there for a second generation in the fall. Adults of this generation did not become sexually mature that season. The two periods of development of hopperburn coincided with the development period of the two generations of nymphs. This species has previously been credited with four generations in Minnesota, five in Iowa, while one enthusiast, not to be outdone, announced six for Mississippi, although there is not a single suggestion that any continuous breeding work from generation to generation had been done to verify these preposterous statements. By reference to the charts it will be seen that there would be adults, eggs, and nymphs present on the vines in numbers continuously from the middle of June until frost and this was apparently the only justification for the use of the mathematical method.

The most carefully worked out study of the life history of a leafhopper ever published was made by Fred Johnson on the shores of Lake Erie in 1912. Johnson succeeded in keeping the grape leafhopper, which winters as an adult, alive in cages through the summer and on into September and obtained from 115 to 140 eggs apiece deposited through a period of more than 60 days. He found a single complete generation of nymphs extending from June to October, a period long enough so that three individuals could have successfully matured. Only the very earliest adults of the developing brood appearing in July ever mated and the resulting production of nymphs of a partial second generation was so small as to be almost negligible. Con-

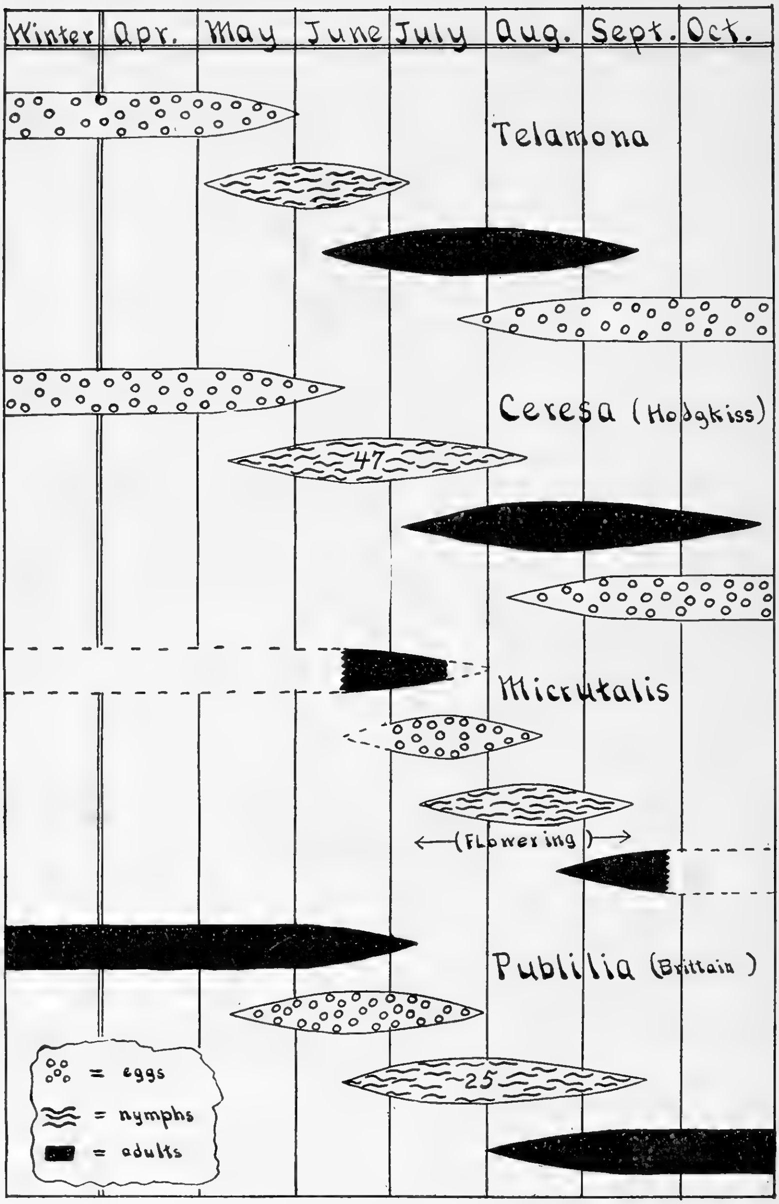
trasting with this Quayle in California found that this species had two generations and appearing a month and a half earlier, but concluded its development equally early in the fall as is characteristic of the southwest region. The grape leafhopper had, by practically all superficial workers been credited with a considerable number of generations. Slingerland, by careful and thorough work, reduced this to a possible two. Quayle, under the most favorable possible conditions for a continual production of generations, was unable to find any trace of mating or reproduction in the second brood adults. He did not, however, follow his first generations through and it may possibly be that the second generation was not a complete one even in that region.

The writer has shown that in the single brooded beet leafhopper the nymphal period varies from April and May in Arizona to July and August in Idaho, and that there are all gradations in the intervening regions without changing the single brooded condition. This species is adapted to feeding on the plants of the beet family and the single generation appears in a region at the time when the food plant is making its most rapid growth.

The problem of obtaining continuous cage records from generation to generation, with such delicate and active insects as the major portion of the leafhoppers have proved to be, is one of the greatest obstacles to accurate knowledge of this group and no doubt one of the fruitful causes of the mathematical propensity of some of the workers. There are, however, a number of ways of determining what is occurring in the field and in checking up incomplete cage records, even where there is an apparently continuous production of nymphs and adults. The most important single landmark of the season is the mating period. If mating is observed in abundance a new generation will soon follow. This is the time when flights occur, migration takes place, and at this time males often fly to lights in numbers. If on the other hand a great preponderance of females are found it will be the later stages of the egg deposition period. The males are always the first to mature and then there is a short period during which the sexes are equal while the last remnants of a brood of adults are always females. If males and females are abundant and no mating is taking place, superficial dissection of the female will at once show whether eggs are present. In cases of adult hibernation the fall generation does not mate and no eggs develop that season.

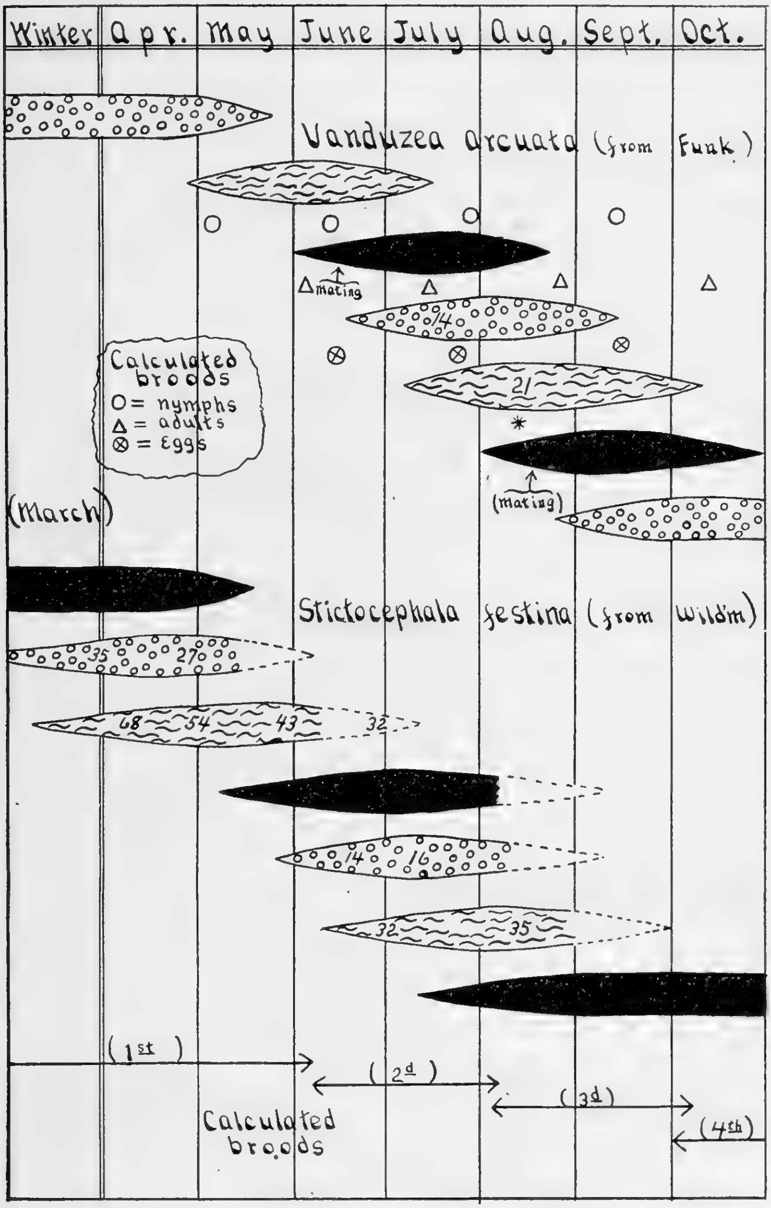
In the HETEROPTERA we find a very similar condition with respect to generations. All species have at least one generation a year while few if any have more than two. Adult hibernation is very common in this group, in fact, it is the rule in a large number of families and occurs in nearly all of them. Mating is very conspicuous and takes place through a considerable period, thus giving a guide to the generations. The eggs in a number of groups are deposited on the leaves and are easily observed.

The chinch bug which used to range from northern Wisconsin to Texas, had two annual generations and adult hibernation throughout. Its relative ,the false chinch bug, appears to have a similar life cycle although a recent writer announces four generations. His four broods were mathematically calculated but he naively noted that it was very difficult to obtain nymphs during two of the periods while during the other two they were abundant.



Winter
Apr.
May
June
July
Aug.
Sept.
Oct.
Telamona
Ceresa (Hodgkiss)
47
Micrutalis
(Flowering)
Publilia (Brittain)
25
= eggs
= nymphs
= adults

E. D. Ball


Winter
Apr.
May
June
July
Aug.
Sept.
Oct.
Vanduzea arcuata (from Funk)
mating
14
Calculated broods
O = nymphs
Δ = adults
⊗ = eggs
21
(mating)
(March)
Stictocephala festina (from Wild'm)
35
27
68
54
43
32
14
16
32
35
(1st)
(2d)
(3d)
(4th)
Calculated broods

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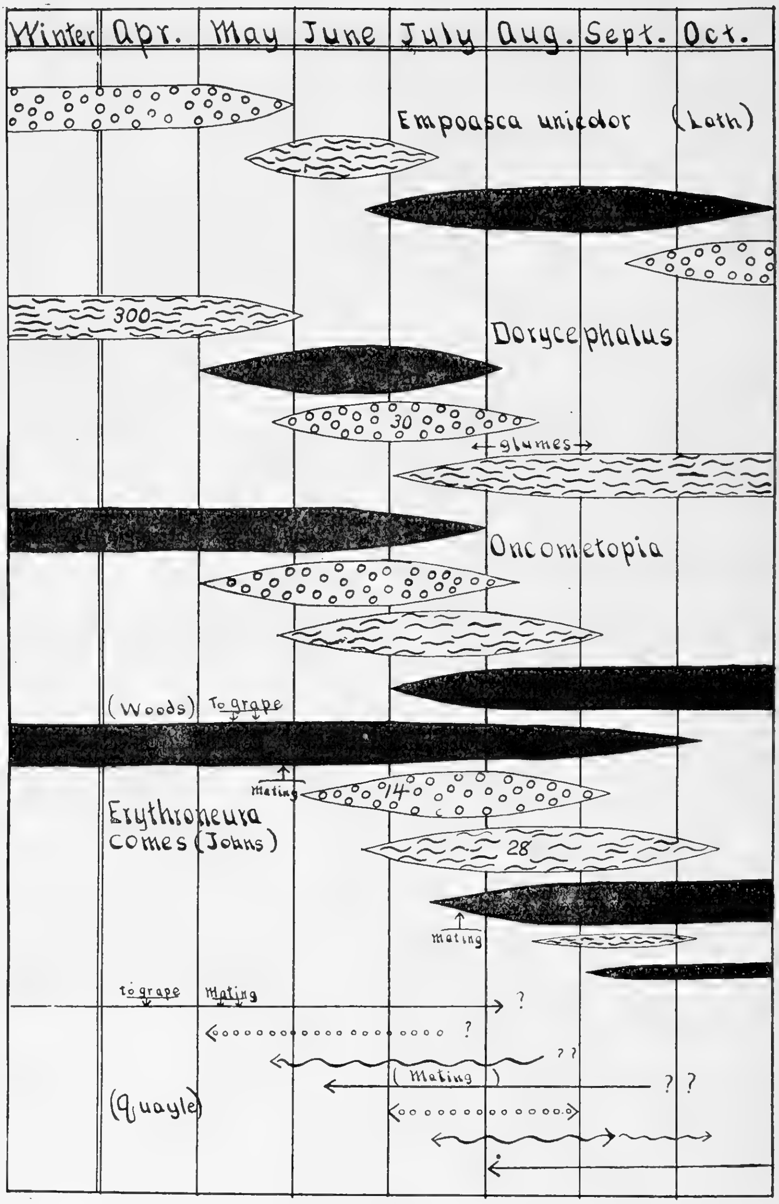
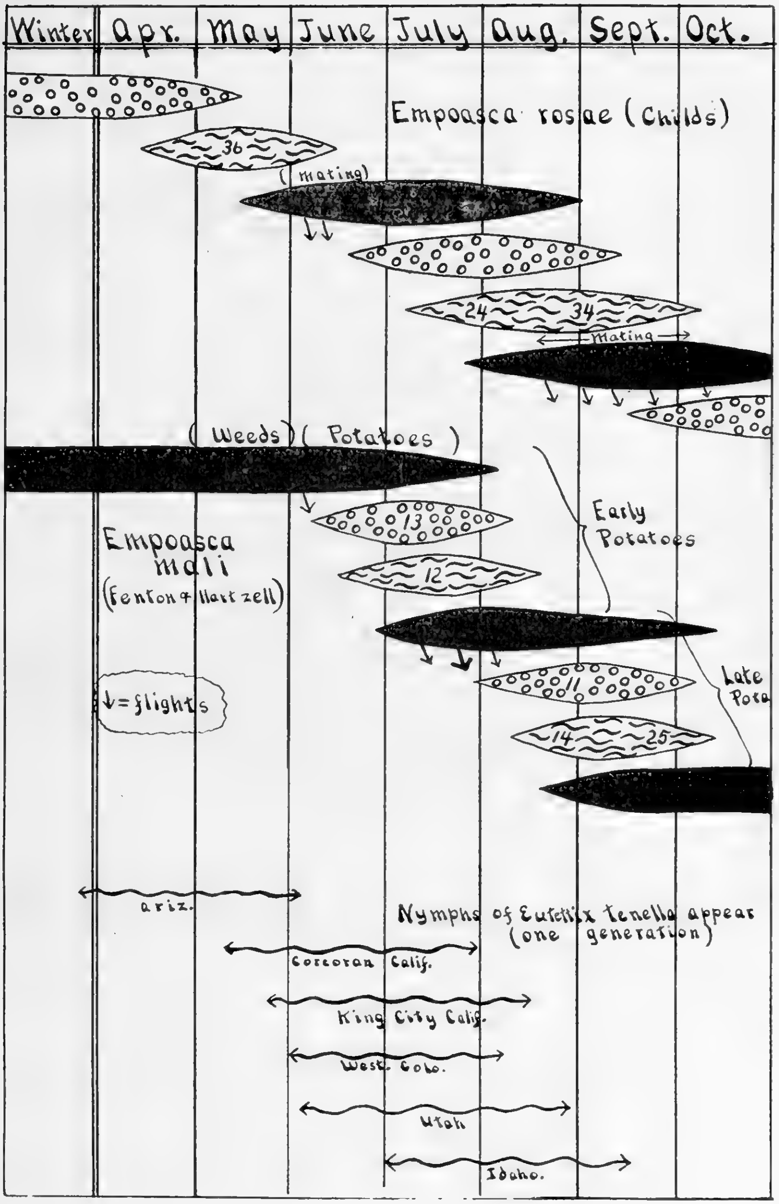

Winter
Apr.
May
June
July
Aug.
Sept.
Oct.
Empoasca unicolor (Lath)
300
Dorycephalus
30
glumes
Oncometopia
(Woods)
To grape
Mating
14
Erythroneura
comes (Johns)
28
Mating
to grape
Mating
?
?
??
(Mating)
??
(Quayle)

E. D. Ball


Winter
Apr.
May
June
July
Aug.
Sept.
Oct.
Empoasca rosae (Childs)
36
(mating)
24
34
Mating
(Weeds)
(Potatoes)
13
Empoasca mali
(Fenton & Hartzell)
12
Early Potatoes
11
Late Pota
14
25
↓= flights
ariz.
Nymphs of Eutettix tenella appear (one generation)
Corcoran Calif.
King City Calif.
West. Colo.
Utah
Idaho.

E. D. Ball

4. THE LIFE CYCLE OF APHIDS AND COCCIDS.*

EDITH M. PATCH,
Maine Agricultural Experiment Station.

APHIDS.

To attempt to epitomize the life cycle of the aphid is like trying to draw an orderly sketch of Chaos. But after all, the confusion may be more seeming than real and certain rules, beset though they may be with exceptions, govern the life of even the aphid.

The gamogenetic egg is an outstanding argument for the conclusion that the aphid of the North is holding more closely to its prehistoric past than are those that spend their lives where the successive seasons of the year offer a constant source of food. For in the region of real winters there is no member of the family Aphididæ (in its restricted sense) whose total life history has been worked out, that is known to pass its annual cycle without exhibiting a concluding generation comprising both sexes. The aphid, then, starts its life cycle like a typical insect—in the fertilized egg.

The overwintering egg is thus true to the traditions of the Hexapods, but with it ends all conventional observances, for between one such egg and the next in sequence there are crowded such phenomena as a succession of parthenogenetic viviparous generations; extreme examples of polymorphism; alternation of generations in a series where a duplication may not occur for seven or more generations; parallel series in which certain females give birth to true sexes without beaks while others of the same generation give rise to normal young which hibernate in the first instar without feeding; and a system of seasonal migration which is not surpassed by any other in the animal kingdom. That all these divergences from the ordinary life cycle for insects take place within the limits of the family Aphididæ would seem remarkable indeed; but it is no less than appalling to realize that the total range of phenomena just indicated may be exhibited by a single species.

*These groups share with other Hemiptera the general heterometabolic or "gradual" metamorphosis, but present a bewildering array of specializations and adaptations.

Papers from the Maine Agricultural Experiment Station: Entomology No.106.

For the purpose of illustrating such a cycle, which will give a representation of the family in the complex estate which many of its members have attained, we might focus our attention on that common, widespread, and well known aphid, *Eriosoma lanigera*, with reference to the outline, Chart II.

I. APHIDIDÆ.

FORMS AND SEQUENCE OF GENERATIONS TYPICAL FOR MIGRATING APHIDS.*

I. Fundatrix	(4)	apterous, parthenogenetic, viviparous female—hatching from the overwintering egg and living on primary host.
II. Spuriæ apteræ	(1)	parthenogenetic, viviparous females—living on primary host.
III. Spuriæ alatæ	(1)	parthenogenetic, viviparous females—developing on primary host and migrating to secondary host.
IV. Spuriæ apteræ	(2)	parthenogenetic, viviparous females—developing on secondary host.
V. Sexuparæ alatæ	(3)	parthenogenetic, viviparous females—developing on secondary host migrating to primary host.
VI. Sexuales		males (4) and oviparous (4) females.
I. Eggs	(4)	on primary host.

(1) The second and third generations, with certain species, may comprise both apterous and alate females; or there may be several generations of either the apterous or the alate females.

(2) There may be two or more generations like IV which are usually counterparts of II.

(3) The fall migrants may resemble III closely or they may differ markedly.

(4) These appear but once in the annual cycle.

* The terms applied to the different aphid forms are very numerous. A tabulation of these for uniform reference would be interesting and convenient but too detailed to be in keeping with this brief paper.

The beautifully elaborated relation of this insect to the nature of its environment, and more the way in which it controls and selects its environment, results in a life history the events of which are as thrilling as a tale of enchantment. The stem-mother touches the unfolding elm leaf with her wizard beak and the magic castle appears with its ample shelter. Its

living wells throb with the sap of growth from which the witch drinks and becomes the giant mother of two or three hundred sireless daughters born at the season when sap runs freely and growth is easy. These in turn give birth to unfathered daughters threatened with disaster. A thousand hungry beaks drain the castle wells of their sap. The floors run with honey dew, and

II. LIFE CYCLE OF *Eriosoma lanigera*. WOOLLY APHID OF THE APPLE.
Seven Generations.

May..........I. Stem-mother (hatching from overwintering egg; causing and developing in rosetted leaf cluster of American Elm).

June...........II. Apterous viviparous female (developing in elm-leaf rosette).

June–July......III. Alate viviparous female (spring migrant flying from elm to apple).

July...........IV. Apterous viviparous female (developing on stem of water-shoot or tender bark of apple).

August........V. Apterous viviparous female (developing on bark of apple—branch or root).

September.....

VI. Apterous viviparous female remaining on apple bark.	VI. Alate viviparous female. Fall migrant flying from apple to elm.
VII. Overwintering nymph, hibernating about crown of apple tree.	VII. Apterous beakless male and Apterous beakless oviparous female.
	I. Overwintering egg in crevice of elm bark.

(This outline is in accordance with the Maine schedule, in which connection it might be stated that the overwintering nymphs are, for the most part, a luckless lot. *Prociphilus tessellata*, however, which exhibits similar parallel cycles brings through the hibernating nymphs with much success).

mold appears. The murderous gangs of capsid, beetle and syrphid enter. And lo, the aphid but unfurls her migrant wings and seeks the juicy stem of an apple, clean and unknown to the enemies of her kind. Her daughters, lacking the leafy shelter of the elm, throw between them and the sun a waxy fluff and thrive. But her great-granddaughters find the bark of the

apple less generous for their needs, and their ancient enemies have smelled their blood and come to slaughter under the roof of wax. And then the migrant, true to the instincts of the clan in the hour of need, quietly escapes and bears the torch of life home to the elm. This voyage of the fall migrant seems inexplicable. It is neither her hunger nor that of her unborn brood that urges her forth for neither she nor her dwarfed, beakless progeny feed on the elm. It is not a quest for a mate, for she, like her maternal ancestors for five generations, gives parthenogenetic birth to her young. But, whatever the cause, once and once only in seven generations the fall migration takes

III. HORMAPHIDINI. LIFE CYCLE OF *Hormaphis hamamelidis*.
(Three generations).

I.	Fundatrix	apterous viviparous female; hatching from overwintering egg; causing and developing within the witch hazel gall; reproducing by parthenogenesis.
II.	Sexuparæ alatæ	Alate viviparous females; developing within the witch hazel gall; dispersing to witch hazel leaves; reproducing by parthenogenesis.
III.	SEXUALES	dwarf, apterous male and oviparous female; both with beaks developing on witch hazel leaves; female laying several fertilized eggs.
I.	Eggs	overwintering on witch hazel.

(For the vicinity of New York, adapted in part from T. H. Morgan and A. F. Shull)

place from secondary to primary host, as once and once only in seven generations the reverse migration of the spring occurs.

Any one such life cycle as that just indicated, though representative, must be specific rather than comprehensive.

An inter-food-plant migration would seem to have become typical of the Aphididæ, for it is met in ten* or more widely distributed tribes; although in many instances the migration is restricted to fresh plants of the same species, a modification that obscures its significance.

That the environment is influential in the production of the winged forms, thus giving the mechanism for migration, is

*Aphidini, Myzini, Macrosiphini, Anoeciini, Mindarini, Schizoneurini, Prociphilini, Pemphigini, Hormaphidini, Pterocommini.

IV. CHERMISINA.* (Life Cycle Typical for Chermes).

	Primary Host, Picea	Intermediate Host, Larix (or Pinus or Abies)
1st Year	I. Fundatrices (hibernate—cause galls—wingless, all ♀ II. Alatæ (larvæ inhabit gall—adults winged, all ♀ Non migrantes — Migrantes	
2nd Year	I. Fundatrices (as before) V. Sexuales (wingless—cause no gall) II. Alate (as before) Non-migrantes — Migrantes to Larix (as before)	III. Colonici (hibernate—cause no gall—wingless, all ♀ larvæ live on the needles—cause no gall all ♀ IV. Sexuparæ (adults winged) — Exsules (adults wingless) Exsules
	I. Fundatrices — I. Fundatrices	?

* No longer included with the family Aphididæ in its restricted sense.

(Adapted from E. R. Burdon, Proceedings of the Cambridge Philosophical Society, Vol. XIII, Pt. 1).

indicated by the circumstance that the best defined examples of migration are exhibited by gregarious species and is correlated with the exhaustion by the aphids of the infested food-plant in the spring and with either that or a normal ripening of the food-plant in the fall. The evidence of Shinji, based upon food tests under chemical control appear to be of especial significance in this respect.

V. PHYLLOXERINÆ.* LIFE CYCLE TYPICAL FOR THE PHYLLOXERANS.

I. Stem-mother (apterous female; hatching from the overwintering egg; causing the gall on hickory and developing within it; laying eggs that develop parthenogenetically).

II. alate female (developing in gall; laying a number of eggs on hickory that develop parthenogenetically to males).	II. alate female (developing in gall laying a number of eggs on hickory that develop parthenogenetically to sexual females).
III. male (apterous, dwarfed, beakless).	III. sexual female (apterous, dwarfed, beakless; laying a single fertilized egg).

I. winter egg (on branch of hickory).

* No longer included with the Family Aphididæ in its restricted sense.

Although the testimony of aphids in the North emphasizes the annual occurrence of the fertilized egg, the parthenogenetic reproduction, which is characteristic for all but a single annual generation, may in many species be indefinitely continued in a warm climate or in hot house conditions (as witness Ewing's 87 generations with *Aphis avenæ*). Whether temperature is the direct control in such cases may be doubted for we have many species producing both alate and apterous forms throughout the summer; and it may be that the continual vegetable growth made possible by the warm climate is the direct encouragement to parthenogenetic viviparous reproduction. This supposition is accentuated by the fact that even in tropical climates experiencing a wet and a dry season gamogenetic eggs are produced to

tide over the period of famine; and in the North some non-migrating species produce the sexes in August, July or even June on exhausted vegetation.

The parthenogenetic type of reproduction, correlated, as it were, with the abbreviated time required for the development of the individual, makes possible the enormous increase of the aphid colony and at the same time minimizes the numerical importance of the gamogenetic egg. We find, then, one of the very striking differences between these and other insects, in the fact that the oviparous female of the aphid never deposits more than a few eggs and in certain tribes one egg only of this character is produced. As if to further emphasize the significance of parthenogenesis for the aphid, certain species (as *Eriosoma lanigera* and *Prociphilus tessellata*) even when dwelling in the North, attempt to provide for a continuation of the apterous, viviparous, parthenogenetic part of their cycle by producing annually nymphs to hibernate about the base of the secondary host at the same time that the migrants are producing the sex forms on the primary host.*

COCCIDS.

The eccentricities of the coccids are concerned with the specialization of their structural characters, and the modified metamorphosis of both sexes rather than with any striking range of habit or peculiarity in sequence of generations; since their typical life cycle comprises between one fertilized egg stage and the next but a single generation composed of both sexes. The extreme possibilities of coccid metamorphosis are illustrated by those species in which the females, at their first molt, lose, for good and all, eyes, antennæ and legs, exhibiting in this atrophy of those organs of orientation and locomotion, a trans-

*In the preparation of this paper repeated attempts have been made to broach the aphid cycle in general terms, a process that would force us to build upon a hypothetical type reminiscent of a primitive condition when each generation was composed of males and females, both alate, and when propagation was solely by means of the gamogenetic egg as is typical for the class Insecta; but not only is such a lost type hypothetical for the aphids, but the processes of divergence have been so marvelously complicated, as concerns structure, habit, and sequence and combination of generations, that the hope of correlating the different groups on any graphic basis has been abandoned; and representative glimpses are all that the accompanying outlines offer.

Appreciative thanks are due Dr. A. C. Baker, Dr. O. W. Oestlund and Dr. Herbert Osborn for reading the paper critically and for certain suggestions that have been incorporated.

formation which has to do with the loss of such organs as characterized them as insects in the first instar, rather than in the acquisition and development of the structures of an adult hexapod. This metamorphosis by reduction, associated with the complete absence of wing development in the female is correlated with the sedentary habit of this family and is in line

VI. COCCIDÆ. GENERALIZED OUTLINE.*

	Male	*Female*
1ST INSTAR	active	active
2ND INSTAR	Xylococcinæ active. Monophlœbinæ active. Eriococcinæ active to near end of period. Diaspinæ quiescent.	active or fixed.
3RD INSTAR	Xylococcinæ quiescent. Monophlœbinæ active. Eriococcinæ quiescent. Diaspinæ quiescent.	active or fixed. Diaspinæ adult.
4TH INSTAR	Xylococcinæ quiescent. Monophlœbinæ quiescent. Eriococcinæ quiescent. Diaspinæ quiescent.	Xylococcus fixed. Monophlœbinæ adult. Eriococcinæ adult.
5TH INSTAR	Xylococcinæ quiescent. Monophlebinæ adult. Eriococcinæ adult. Diaspinæ adult.	Xylococcus adult.
6TH INSTAR	Xylococcinæ adult.	

* This outline is given by courtesy of Dr. A. D. MacGillivray, to whom thanks are also due for a critical reading of the Coccid part of the present paper and for certain suggestions that have been incorporated.

with the atrophy of class structures in parasitic animals. But the suppression of generalized characters does not inhibit the appearance of special structures of a high degree of development, as is beautifully illustrated by the wax glands, marvelous in form and variety, to be found in the coccids; a concentration of structural effort directed toward the secretion of a waxy protection for these sedentary creatures and their eggs.

VII. COCCIDÆ. LIFE CYCLE OF *Xylococcus betulæ.*

Fertilized Eggs.

Male and Female

1ST INSTAR—Indistinguishable, active; antennæ stout, legs long, simple eyes large, rostrum large.

Male

2ND INSTAR—Antennæ and legs stout, body segmentation distinct.

3RD INSTAR—Legs and antennæ lacking. Much like 2nd instar of female.

4TH INSTAR—Developing legs and antennæ present, rostrum lacking, mesothorax shows traces of future wing pads.

5TH INSTAR, Pupa—Developing legs and antennæ long and stout, wing pads broad.

6TH INSTAR, Adult—Compound eyes large and projecting, legs stout, antennæ long, fore wings large and functional, rostrum lacking.

Female

2ND INSTAR—Legs and antennæ lacking, simple eyes minute, body without apparent segmentation, rostrum functional.

3RD INSTAR—Legs and antennæ lacking, simple eyes minute, body without apparent segmentation, rostrum functional.

4TH INSTAR—Legs and antennæ lacking, simple eyes minute, body without apparent segmentation, rostrum functional.

5TH INSTAR, Adult Female—Eyes minute, rostrum lacking, legs and antennæ stout, body segmentation well defined.

Young are produced oviparously.

(Adapted from Hubbard and Pergande.)

The metamorphosis of the male coccid falls in line with that of the female for the first, and in many respects for the second instar.

Then, as though the somatic memory of Hemipteron inheritance reclaims its own, the insect reverts to the methods of the order to which it belongs and develops antennæ, legs and wings by the external gradual process proper to the Rhychota. In the confusion, however, between the generalized Hemipteron transformation by gradual external development of adult characters, and the specialized tendency of the parasitic coccid toward atrophy of these same characters, the male, attempting both, accomplishes neither in typical shape; but strikes a happy medium all his own by passing through his latter nymphal instars beakless and quiescent, and emerging a queer atom of an insect in possession of remarkable eyes, well developed legs and antennæ, and usually functional wings (albeit there is little left of the hind pair but the costal hooks), but lacking curiously enough the only emblem of Homopteron relationship which his wingless, eyeless,* legless,* antennaless*, mate can boast—the beak*.

The biological urge for overproduction is chiefly provided for, among the coccids, by the great number of eggs deposited rather than by a conspicuous shortening of the life term of the generation. Coccid eggs are typically fertilized though there are many instances of parthenogenetic eggs recorded. Parthenogenesis in the coccids, however, does not seem to function toward a greater number of generations per season as with the aphids but is merely an alternative of certain species. This is also the case with the ovo-viviparous reproduction of those species where the egg undergoes complete development and hatches within the body of the living female; a process which does not carry the significance of the viviparous reproduction of aphids.

Except for those species for which apterous and alate males both occur, polymorphism is not exhibited by the coccids, nor do they have an alternation of generations—one being like another in form and habit. Perhaps nowhere else among the insects, however, do we find a more excessive difference in the two sexes than in the extraordinary dimorphism of the coccids.

*This, of course, can not be said of the whole family. The female, *Xylococcus betulæ*, for instance, *possesses* eyes, legs and antennæ and *lacks* the beak!

VIII. Life Cycle of *Aspidiotus perniciosus*.

Fertilized Eggs.

Male and Female

1st Instar (12 days), indistinguishable—Legs, antennæ, rostrum and simple eyes present; active.

Male

2nd Instar (6 days)—Eyes large, beak functional, legs and antennæ lacking.

3rd Instar (2 days)—Rostrum lacking, developing eyes large, wing pads and developing antennæ and legs all external and free; inactive.

4th Instar (4 to 6 days)—Head, antennæ, legs, wing pads and style are well formed, rostrum lacking.

5th Instar, Adult—2 wings; legs, antennæ and eyes functional, rostrum lacking.

Female

2nd Instar (8 days)—Simple eyes, legs and antennæ lacking, rostrum functional.

3rd Instar—Adult, produces young for 6 weeks. Legs and antennæ lacking and rostrum functional.

Young are produced ovi-viviparously, the fertilized eggs undergoing development within body of the female. (Sometimes oviparously.)

(Adapted from Pergande, 1895.)

The sedentary habits of the female scales leave the natural dispersal of these insects to the first instar larvæ so that, except for accidental carriers, the spread is characterized by its thoroughness rather than by its breadth.

The most congenial conditions for the coccids are found in warm climates, and there are comparatively but few species whose life cycles are attuned to regions having severe winters.

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5. THE LIFE CYCLE OF THE LEPIDOPTERA.

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Coming at the point in this program between discussions of heterometabolous and holometabolous development, it seems necessary for us to diverge a few moments from the subject as printed, to consider the biological significance of complete metamorphosis.

The structural basis for the distinction between these two types of development has been repeatedly described. Studies histological, morphological, and physiological, have been made on the ontogeny of the different parts of the insect body, in ametabola, heterometabola, and holometabola. Uniformity has been discovered in wing development, cell structure, and body sclerites within each of these groups until we may say that the basis for the three great subclasses of insects rests on a solid foundation in morphology.

The biological significance of these groups, on the other hand, has usually been overlooked. The environmental problems which evolution is called upon to solve, if we may be permitted to express the situation in this way, become immensely complicated as the number of different forms taken on by a single individual increases.

Speaking biologically then, insects without metamorphosis exist in, and are thus adapted to, a single environment, both the form and the surroundings remaining the same throughout the life of the individual. With the arrival of wings, an increase in the number of activities causes an enlargement of horizon and introduces some degree of variety in the character of the

surroundings. Typically, heterometabola, except when aquatic, retain the same environment throughout life and the adults face practically the same ecological conditions as do the immature, wings simply increasing the chances of survival.

Insects with complete metamorphosis all differ from those with incomplete, in one respect: to each individual three environmental problems are presented. The larva must find an adequate food supply, the pupa protection against enemies and hostile physical conditions, and the adult opportunity and means for reproduction. The abundance of the available food, which includes every kind of organic matter, elaborated in any way by any vegetable or animal organism, reduces the complexity of the situation. Rapidity of locomotion, however, one of the most effective means of escaping adverse conditions, has been uniformly reduced or lost in holometabolous insects. For the latter, therefore, the problem of utilizing the food supply is one of protection against enemies and weather during the period of growth.

If we now turn our attention to the position of the Lepidoptera among other holometabola we find that the four major orders have solved this problem of protection in four different ways. The Coleoptera use the combative method of fighting the struggle for existence. Clad in armor in both larval and adult stages they exist on the hardest wood, prey on the most agile insects, or burrow within the soil. The Diptera, on the other hand, have adopted the path of least resistance. While the armed beetle larva hides in caves and burrows, the dipterous maggot is concealed deep in rotting vegetation, in the stomachs of mammals, or the body juices of other insects. Even the predacious Syrphid larvæ attack only the softest, most helpless of all insects, the plant lice.

Hymenopterous larvæ, excepting the Tenthredinoidea, have, if anything, gone farther. Many still "rustle for themselves" but in the more specialized predatory families even the host insects must be paralyzed by the parents before the larvæ can successfully attack them. Finally the last step is reached among the bees and ants where the young must be fed, warmed and cared for day by day, so utterly helpless that they can not even be furnished with an adequate supply of food and left to consume it alone.

Of all the major orders, in only one, the Lepidoptera, have the larvæ attempted to meet the conditions of life as it exists and, with minimum protection, succeeded solely through their immense vitality.

If the uniformity within each dominant order is remarkable, the variety is no less so. The differences between the nearly fifteen thousand species of Coleoptera in the United States are primarily variations in essential chitinized structures. Number and position of legs true and false, number of claws, shape and arrangement of mouthparts, head skeleton, cerci, and chitinized plates are all evident. In the Diptera structural differences are equally numerous; the soft parts such as body shape, and the respiratory system are also various. Dipterous larvæ depart farther from typical arthropod structures than other orders.

In the Hymenoptera structural divergences (once more excepting Tenthredinoidea) almost disappear and variation in social organization and methods of securing food take their place.

Again the Lepidoptera are unique. With a fundamental structure so constant that logical classification long appeared to be baffling, superficial differences in the larvæ are extremely numerous. One finds remarkable uniformity in all the principal features of anatomy. The same number and position of thoracic legs and prolegs, the latter nearly always with chitinized hooks, the same form of head, the same kind of mouthparts, the same number of spiracles and segments. Exceptions, except among the few leafminers, are trifling.

In superficial characters the reverse condition, variety, is just as marked. Using one fundamental setal pattern, the most diverse arrangements are presented. A sensitive area in one family develops a single seta, in another, a tuft on a wart, in another, a group of soft hairs on a flat plate, and in still another, a bunch of poisonous spines. If we examine the arrangement of the hooks on the prolegs we will note variations equally significant.

FOOD SUPPLY

Table I shows the remarkable uniformity in source of food supply in the Lepidoptera. The members differ from other orders in being confined almost entirely to chlorophyll-bearing plants. The exceptions are entirely among the more primitive

microlepidoptera. In the families in which the mode of life has become static, the species are limited not only to the kind of plant, but are, except in a few Noctuidæ, confined almost wholly to leaves of terrestrial flowering species.

TABLE I. FOOD SUPPLY.

Order, Family, or Super-Family	Plant Material										Animal Material				
	Living Terrestrial Flowering Plants					Aquatic Plants		Dead Plant Material		Fungi	Living		Dead	Dried	De-cayed
		Borers						Dried	De-cayed		Parasites or Predators				
	External Leaf Feeders	Leaf Miners	Herbaceous Stems	Woody Stems	Fruit and Nuts	Externally	Borers, Leaf-rollers, or Webbers	Grain, Flour, Fruit, Nuts	Leaf-mold, Fruit, Veg-etables	(Except occasionally Fungous Spores)	On Invertebrates	On Vertebrates	Meat, Cheese, Fats	Wool, Fur, Honeycomb	Dung Carrion
NEUROPTERA											X				
MECOPTERA											X				
TRICHOPTERA						X					X				
LEPIDOPTERA	X	X	X	X	X	(X)	(X)	(X)			(X)			(X)	
Tineoidea	X	X			X			X			X			X	
Tortricidae	X				X										
Aegeriidae				X											
Cossidae				X											
Psychidae	X														
Gelechioidea	X	X	X		X			X							
Pyralidoidea	X		X		X	X	X	X			X			X	
Zygaenoidea	X										X				
Geometridae	X														
Lasiocampidae	X														
Liparidae	X														
Notodontidae	X														
Noctuidae	X		X		X		X								
Arctiidae	X														
Saturnioidea	X														
Sphingidae	X														
Hesperioidea	X														
Lycaenoidea	X														
Nymphaloidea	X														
Pieridae	X														
Papilionoidea	X														

NOTE—Parentheses indicate rare or unusual sources of food for the group named.

Returning to our original figure of speech, nature has taken a fundamental structure and a relatively constant environment and through superficial modifications has developed a great dominant order. She has exposed the members to every form of attack from parasites and enemies. She has made them both conspicuous and slow, with only moderate fecundity. But by providing them with the most universal and abundant source of food she has so developed their vitality that they have become

one of the four largest groups of ordinal rank in the animal kingdom.

The few exceptions to the phytophagous habit include such very rare parasites as the Xylorictidæ, and a few predators such as one or two pyralids living on scale insects. Possibly the clothes-moths and the wax moths, living on animal products, might also be called carnivorous. None are parasites on living vertebrates.

TABLE II. MEANS OF PROTECTION.

Order, Family, or Super-Family	Structural							External							
								Natural					Artificial		
	Hairy	Non-Poisonous Spines	Poisonous Spines	Eversible Glands (Repugnatorial?)	Sting or Bite	Defensive Coloration	Conspicuous; No Protection?	Leaf Miners	Leaf Rollers	Stem Borers	In Fruit or Nuts	Hide In Soil	Silk Web or Cocoon	Case of Foreign Materials	Nest Containing Many Larvae
NEUROPTERA					X							X			
MECOPTERA					X							X			
TRICHOPTERA				X										X	
LEPIDOPTERA	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Tineoidea								X			X		X	X	
Tortricidae						X			X		X				X
Aegeriidae										X					
Cossidae										X					
Psychidae														X	
Gelechioidea						X	X								
Pyralidoidea	X					X			X	X	X		X	X	X
Zygaenoidea	X			X											
Geometridae						X	X								
Lasiocampidae	X														X
Liparidae	X		X	X											X
Notodontidae	X	X		X		X	X								
Noctuidae	X			X						X	X	X			
Arctiidae	X														
Saturnioidea		X	X												
Sphingidae						X	X								
Hesperioidea						X			X						
Lycaenoidea				X											
Nymphaloidea	X	X		X											
Pieridae						X	X								
Papilionoidea				X		X	X								

FORMS OF PROTECTION.

In Table II the possible forms of protection against adverse conditions are shown divided into "structural" and "external" classes; the former depend on anatomical adaptation, the latter on habit and mode of life. Here as in Table II, the division

between microlepidoptera and the macros appears plainly and has greater biological significance than the division into moths and butterflies.

The members of the first half of the order, the microlepidoptera, show the anomalous condition of greater variety of habitat and food supply, associated with a most extraordinary uniformity in structure (excepting in leaf miners). Nearly all the exceptions to rules occur in this group. In the more specialized suborder on the other hand, one finds remarkable uniformity in habits and food but a great variety of superficial appearance.

The two most common forms of protection in Lepidopterous larvæ are (a) the development of tufts of setæ and (b) the construction of a nest or case. Silk glands are of universal occurrence but are used in many different ways with different results. The effective value of tufted setæ against birds, parasites, and predators is well known.

LIFE CYCLE.

Leaving these general considerations of lepidopterous development, a brief statement on the length of the life cycle should be included in a paper on this subject. Typically the life of a lepidopterous insect consists of (a) an egg stage, the egg simple in structure and seldom concealed; (b) the larval period, of five to seven instars; (c) the pupal condition, protected by a cocoon, or, in form, a chrysalis; and (d) the adult relatively constant in structure, and various in appearance like the larva.

The number of broods is limited, Table III showing the conditions in economic species in the northern States. One or two broods a year are the rule, longer or shorter life cycles being exceptional. The writer is familiar with no cycles longer than one year outside the family Cossidæ.

More than three annual broods occur only in the southern states or under conditions where breeding throughout the year is possible. Seven broods in one year in a species living in grain (Angoumois grain moth) seems to be the maximum authentic record.

The winter is usually spent as a larva, often followed immediately by the pupa in the spring without resumption of feeding. This is true in both one and two brooded species. In some single-brooded forms the egg stage is the hibernating condition

while in a few species the pupa or adult manages to survive the winter.

The fundamental basis of lepidopterous development appears to be the combination of a universal food supply with a remarkable uniformity in structure in all stages. Thousands of species

TABLE III. BROODS AND HIBERNATION.

Family or Super-Family	No. of Spp. Rec.	Broods					Hibernation				
		½	1	2	3	4–6	E	L	P	P-A	A
Tineoidea	6		4	2		(2)		3	2		
Tortricidae	13		3	8	2–(2)		3	6	3		
Aegeriidae	4		4	(1)				4			
Cossidae	2	2						2			
Psychidae	1		1				1				
Gelechioidea	2				1–(1)	(1)		1			
Pyralidoidea	17		4	8	3	(8)		8	3		
Zygaenoidea	1			1					1		
Geometridae	7		6	1			4	1	1		
Lasiocampidae	2		2				2				
Liparidae	5		5				4	1			
Notodontidae	3		3	(1)				1	2		
Noctuidae	18		6	10	1	(4)	1	4	7	2	1
Arctiidae	5		4	1				5			
Saturnioidea	3		3				1		2		
Sphingidae	6		6	(2)					6		
Hesperioidea	1					(1)					
Lycaenoidea											
Nymphaloidea	1			1							1
Pieridae	3				2	(3)					
Papilionidae	1			1							
Total (Nearctic)	101	2	51	33	9		16	36	27	2	2
(Subtropical or protected)				(4)	(3)	(19)					

Note—Parentheses indicate the life history in the southern states or under indoor or stored-product conditions.

E—Egg; L—Larva; P—Pupa; P-A—Emergence during hibernation reported; A—Adult.

have evolved, all different in appearance, armature, and superficial characters, but remarkably alike in functional external organs of ingestion and locomotion. The "butterfly" is the proverbial example of superficiality but the lepidopterous larva and adult have such a healthy, tremendously vital basis on which to build that they must be considered in every sense successfully adapted to their world.

6. THE LIFE CYCLE OF THE COLEOPTERA (Including the Strepsiptera).

Royal N. Chapman, University of Minnesota.

The magnitude of variations in the life cycle and form changes which are met with when the Coleoptera and the Strepsiptera are considered as a group are hardly exceeded by any other group of insects. When we remember that there are now considered to be more than one hundred families of Coleoptera containing, in all, over one hundred and fifty thousand species, it is not surprising that there is a great amount of variation.

Some of the standard works on the Coleoptera might lead one to believe that beetles have no larval or pupal stages, for they are not mentioned. When Buetenmuller published his catalogue of the described transformations in 1891, the eggs had been described for 52 species, the larvæ for 368, and the pupæ for 96 species in North America. While a considerable amount of progress has been made since that time it has been only during recent years that attempts have been made to correlate the knowledge of the transformations of even the smaller groups.

It is difficult to obtain accurate information with regard to the various life cycles, especially with regard to the conditions which cause variations in the duration of the various stages. The data on which this paper is based have been taken in part from statements in literature which seem to be dependable, and in part from original experimental evidence.

The type forms of the various stages of the life cycle are subject to great variation throughout the group. The majority of the eggs are laid singly and unprotected, but the hydrophylid eggs are in covered cases and some of the Carabidæ deposit their eggs in cases constructed of mud. The egg stage is eliminated among at least some of the Strepsiptera which are viviparous.

The commonest larval form is campodiform or eruciform, being elongate and possessing thoracic legs, but all types of larvæ are represented. The generalized carabid larvæ are

typically campodiform, some of the Tenebrionidæ may be taken for the eruciform, while certain of the Buprestidæ, Cerambycidæ, Ipidæ and others represent the apodiform type.

The metamorphosis is complete, but there are cases of hypermetamorphosis. Among the Meloidæ we have this specialized type of development which illustrates, in a single species, all three types of larvæ, the campodiform, the eruciform (perhaps more scarabeoid) and the apodiform. There are other changes of form from one instar to another in the case of *Taphrocerus* (Buprestidæ) which hatches with the structure of a typical wood borer, but which appears later with the structure of a typical leaf miner. Some of the Bruchidæ have small functional thoracic legs in the first instar, but after they enter the nutrient substance in which the remainder of their life is to be spent, they become apodiform.

The pupæ are usually soft and protected from evaporation by a cell formed from materials of the environment cemented together by a secretion. However, some of the leaf miners which pupate in the leaves where the thin epidermis gives them little protection (*Taphrocerus*, Buprestidæ) are covered with a coat of chitin.

Most adult beetles are similar in general form, but the Platypsyllidæ are parasitic upon beavers and resemble other parasites which live upon vertebrate hosts. Indeed they were first described as Mallophaga. Specialization has led to degeneration in the case of the rhipaphorid parasite of the cockroach, the female of which is larviform. Among the Strepsiptera there are cases which have gone much farther and the female is a sack-like organism without means of locomotion which remains attached to its host throughout its life and from which the young emerge as larvæ.

The number of broods, the length of life and the number of molts are of the greatest significance in this consideration. These are interdependent and inseperable. There is no great uniformity in these respects when the group is considered as a whole nor is there always constancy even within a single species. Changes in certain environmental factors may alter the number of broods, change the length of life and the number of molts. But it should not be concluded that a change in a certain factor will cause a change in all species, or that some species can be changed at all. Nor are we justified in concluding, a priori,

that even the inherent tendencies toward periodicity may not be altered. In general those forms which are found in more or less uniform environmental conditions respond most readily to changes of the environment. Examples of this may be found among the beetles which live in stored food products. On the other hand, the beetles which feel the effects of the periodic changes of the season, having their food available for a limited period of each year, often have developed a periodicity with regard to their life phenomena.

Tribolium confusum has its egg stage shortened from ten to five days by a rise of from 24° to 34°, and it will develop one generation after the other throughout the year. On the other hand, the life cycle may be prolonged by a reduction of the amount of moisture and also by a limitation of the quantity or quality of the food. Thus the length of life and the number of broods may be altered by changing any one or all of these three factors. A larva now under observation has had its life prolonged from thirty to ninety days due to food conditions, and during this time it has molted twelve times rather than the normal six times.

So far as is known, all beetles have their lives shortened by an increase of temperature, over that which they normally experience. But some of them will not produce more broods in a year under high temperature than under low. The cotton boll weevil, a native of the south, has been reported to have as many broods a year as time, temperature, and humidity will allow, but the potato beetle always has two broods a year. Those forms which are not subject to an inherent periodicity have more broods in the south than in the north, but those with a fixed periodicity cannot be so changed. Shelford reports that a certain cicindelid has the last larval instar prolonged to extend over the period of hibernation in Canada, while the same species has a shorter larval life in the vicinity of Chicago.

The Buprestidæ as a family hibernate in the larval stage, but *Taphrocerus* which mines in the leaves of the floodplain bullrush as a larva, emerges and hibernates in the adult stage. In this case the larval life is confined to about six weeks in the early part of the summer and the adult beetles emerge and feed about on the leaves, but no eggs are deposited until the following spring. On the other hand, the larvæ of *Agrilus bilineatus*, a wood-boring buprestid, may mature in August and form their

pupal cells, in which they will remain as larvæ until the following spring, even though the temperature rises during September and there is ample time for them to transform and emerge as adult beetles. However, there would not be time for the eggs to be deposited and hatched and for the larvæ of the next generation to penetrate the bark of the tree before winter.

Among some of the Staphylinidæ which are reported as being symbiotic with ants, the larval life is said to be only fourteen days. On the other hand there are cases reported in which certain of the Cerambycidæ have been known to live as larvæ for years in dry wood.

If a statement were to be made with regard to the usual length of the egg stage of the Coleoptera as a whole, it would probably be to the effect that the egg stage is normally ten days in length. The Staphylinidæ already referred to as being symbiotic with ants, have an egg stage which is said to be of only two days duration. Still others of this same family have no egg stage at all. Several species of the Chrysomelidæ and the Strepsiptera are also viviparous.

The adult life is no more constant throughout the group than the other stages are. The adult life of many beetles coincides roughly with the growing season, although some of the Carabidæ have been observed to live for more than a year. Adults of the genus *Tribolium* have been kept for more than a year at room temperature and oviposition continued throughout this period. The males of some of the Strepsiptera are reported as living but fifteen or twenty minutes of extremely active life, while the females, in the absence of the egg stage, must live a more prolonged life in order that the young may develop within them.

The larvæ molt their skins in a more or less periodic way. Five or six instars may be considered as common, but among some of the Buprestidæ and others the number of molts may be increased when the larval life is prolonged as a result of unfavorable environmental conditions. One of the Tenebrionidæ has already been referred to as having had its life prolonged to three times the normal period during which time it has molted twice the normal number of times.

To turn to the consideration of the significance of these facts in relation to the environment it is necessary to avoid being lost in a vast amount of detailed information. In this

limited space it is possible to make only a few generalizations. A precaution may well be taken with regard to the use of the word "adaptation." In the minds of some of the modern biologists it is not orthodox to even mention this word. Therefore this word will not be used, but attention is called to the fact that the insects of this vast group are fitted into the environment wherever they will fit, with the result that certain type forms, together with certain biological characteristics, are to be found in the different types of environment.

There is a considerable group of aquatic beetles. Some of the larvæ crawl about over the submerged vegetation and resemble some of the neuropteroid larvæ of the same habitat as much as they do other closely related Coleoptera. In the swift water of a lotic environment the limpet-like larva of *Sphenus* is to be found.

A large group of beetles typified by the Carabidæ is found on the ground and under its cover of debris. The campodiform type of these larvæ has already been referred to and it is to be noted that this same type form is to be found among all surface feeding larvæ whether they feed upon the ground as the Carabidæ do or whether they are slightly modified for feeding upon the surface of plants as the Chrysomelidæ and Coccinellidæ do. These type forms, however, are characteristic of the families only in so far as the species retain the typical habits of the families. The family Chrysomelidæ has certain members which feed upon aquatic plants and these species have departed from the family type and have taken on various specializations leading to a virtual apodiform condition in some species.

Another great group of beetles passes the larval life within the nutrient medium. Some of these make their way through a hard substance with a great deal of effort and are typically apodiform. They are highly specialized for this mode of life and are helpless upon an exposed surface. Others which are normally found in softer substances may have well developed thoracic legs, as in cases where it is necessary for the larvæ to pass through a large amount of substance in order to accumulate enough nutrient material for maintenance and growth. Still others which live in a soft medium of high nutrient value may have limited means of locomotion and the entire larval life may be spent in a very limited space.

The more complicated life cycles have the most extreme changes of form connected with them, such as have been referred to in connection with the form changes of the larvæ. The Meloidæ are the best examples of this specialization, including such examples as *Epicauta*, the larva of which is at first campodiform and free living, but after it has located the egg pod of one of the Orthoptera, it enters into an arcuate larva with greatly reduced thoracic legs. Thus we have in a single life cycle a combination of the free living and restricted habits of life and they are accompanied by the typical larval forms which are to be correlated with them.

The impress of climate on the life cycle of the beetle is unmistakable. However, the effect of temperature upon the length of the various stages has already been referred to in connection with the length of life cycle and will not be discussed further.

Food is a factor which, like climatic conditions, may alter the length of the cycle as a whole or certain stages of it. This factor has been greatly neglected and a better understanding of it will undoubtedly be a great aid in bringing order out of the confusing detail which is to be met with in studying the biology of the Coleoptera.

The herbivorous beetles which are dependent upon growing plant tissue for their food may be said to have the factors of food and climatic conditions more or less merged into one. Conditions which favor the growth of plants favor the food supply, and thus control the growth and development of the beetles.

Beetles which live within their nutrient medium may be in the leaves of plants, in the fruiting bodies, or they may be in the supporting structures such as wood. These forms lend themselves to experimentation, for it is possible to correlate their rate of growth with the nutrient value of the material in which they live. The wood boring forms are notoriously long lived and the leafminers are usually short lived. Here with conditions of temperature and humidity constant it is possible to prolong or shorten the life cycle by controlling the nutrient value of the food.

The relatively simple condition just cited merges into a more complicated condition met with in the forms which are termed scavengers. While these forms appear to be subsisting upon

dead plant and animal matter, this material is teeming with life. The basic processes of amonification, nitrogen fixation, and the synthesis of proteins are being carried on by these micro-organisms and the beetle which feeds upon this decaying matter profits by their activity. It has been shown, in the case of some insects, that under certain conditions the rate of growth is in direct proportion to the number of micro organisms in the food.

One has but to review the food lists of the beetles to note in how many cases they are known to feed upon fungi or upon substances which may well contain micro organisms. When this subject has been investigated further we may come to a newer and more rational undertsanding of the life cycle of the Coleoptera.

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7. THE LIFE CYCLE OF THE DIPTERA.

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In attempting a summary such as this, one is almost dismayed by the great gaps in our knowledge of even the commonest species. Doubtless many of the gaps in what follows could be filled by a more careful scrutiny of the literature; many more, I am sure, could be filled from unpublished records and observations of the members of this Society; but when all this is recorded we shall find that very much more investigation must be performed before we can so much as give a comprehensive statement for all the species of a single family or for a single species of each family.

I do not believe that the order Diptera is surpassed, either within or without the class Insecta, for variety of habits and complexity of bionomics; and it seems to me an impossible task to present in a brief paper anything like a satisfactory picture of the life-cycle of the flies.

Not only is data wanting for more than a fraction of a per cent of the species; but, moreover, in the families where our knowledge is more complete, the most impressive thing is that *there is no agreement or uniformity of habit.* Where uniformity appears in my statements it is possibly because we know only a few of the many species in that group.

The Diptera all belong to the group variously known as Endopterygota or Holometabola or insects with a complete metamorphosis. Egg, larva, pupa and adult are very distinct from each other and usually well separated both structurally and ecologically. In fact, I have not been able to think of a single case in which the two active stages, larvæ and adults, occupy the same habitat and utilize the same kind of food. The nearest approach to it appears to be in some scavenger forms in which the adults and larvæ may both partake of the decaying material—in somewhat different condition, however; and the habitats of the two stages are very different. The blood-sucking habit is common for the adults, but the larvæ of these species have different habits. Even in the case of the obligate, parasitic, blood-sucking Hippoboscidæ, the larvæ are nourished, not by the host directly, but within the parent fly. And in the few cases where the larvæ are blood-sucking (Auchmeromyia) the adults appear not to do so.

If one were to point to a single factor which has had most influence upon the life cycle of the Diptera it would seem to be the habits of the larvæ. This, as we shall see, determines to a large extent the habitat of the egg and it has likewise a profound effect upon the specializations and adaptations of the pupa stage and to a lesser degree upon the habits of the adult, particularly upon oviposition.

Certain prominent lines of specialization are familiar to all. There are the aquatic species with their host of specializations and adaptations in egg-laying, for the maintenance of the egg in this precarious environment, for the locomotion, defense and respiration of the larva; for the maintenance and preservation of the pupa and for the emergence of the adult.

There are the numerous parasitic species with the perfection of the instincts for locating prey, many unique contrivances for safeguarding the eggs, interesting adaptations which enable the larva to reach its feeding grounds and to maintain itself variously as an external, a subcutaneous, a gastric, an intestinal, a nasal, an auricular or a vaginal parasite.

There are scavengers of all degrees of specialization; there are fruit flies and leaf miners and gall-making species and borers in root and stem; each showing peculiarities not encountered in the other groups and each, indeed, far removed from what must have been the original structure and habit of the ancestral forms.

The species of aquatic, scavenger, or parasitic habits are free from the restrictions governing the development of those species dependent upon living plants, but the life-cycle of the gall-makers, leaf miners and fruit flies is often built around the annual cycle of the host plant and we find many nice adaptations for the utilization of the potentialities of the plant tissues by attacking them at the exactly right time in their development.

THE EGG.

The egg stage shows many adaptations to its environment and in anticipation of the welfare of the subsequent larva.

The adults lack a definite ovipositor of chitinous appendages yet the terminal abdominal segments may be adapted to insert the eggs into the softer tissues of plants, fruits, etc., as in the Trypetidæ. Much more frequently the eggs are simply dropped, deposited, or glued to the surface of the substratum, on or in which the young may find nourishment. They may be (*a*) laid singly, (*b*) arranged in indefinite, irregular blotches or masses, (*c*) ranked with some definiteness but not fastened to each other, or (*d*) most carefully arranged in a definite manner with respect to each other, and fastened with a cement-like secretion. The cyrtid female expels the eggs forcibly in great numbers while hovering up and down a tree trunk (King*); conopids attach them to their host while in flight; sarcophagids will drop their young through a screen to food material some distance below. The interesting manner in which the female *Culex* holds the first few eggs upright between her crossed hind legs until enough can be fastened together to make the raft float has been described by Howard, et al.† Miall‡ describes some beautiful adaptations by which the eggs of aquatic Diptera are moored at the surface of the water. *Chironomus* eggs are laid in gelatinous ropes that are held in place by peculiarly twisted threads. The raft of *Culex* eggs floats by its own convexity, the single eggs of *Aedes* and *Anopheles* have curiously moulded air floats to decrease their specific gravity. The female ephydrid may crawl under water to fasten her eggs to submerged objects.

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*King, J. L. Observations on the Life History of Pterodontia flavipes Gray, *In* Annals Ent. Soc. Amer., IX, 3. Sept., 1916, 315.

†Howard, Dyar and Knab, The Mosquitoes of North and Central America and the West Indies.

‡Miall, L. C. The Natural History of Aquatic Insects.

All the eggs may be matured and extruded at one period, after which the female usually dies rather promptly. Among Leptidæ and Simuliidæ several females may contribute to the same egg-mass and their dead bodies are found together. Or the eggs may mature in definite batches at successive intervals. Or they may mature gradually and continuously and be laid over a period of several days as matured.

It is puzzling to explain certain indirect methods by which the larvæ are obliged to reach their proper feeding grounds. The human bot fly, *Dermatobia cyaniventris* is said to lay eggs on the bodies of a mosquito which serves as the porter for transference to a warm-blooded host, the contact with which causes prompt hatching. The well-known cases of the common Oestridæ in which the eggs are laid on a part of the body of the host remote from that occupied by the larva would seem to be a highly inefficient habit. The eggs of certain Syrphidæ may be laid on plants in anticipation of the usual subsequent infestation by aphids on which the young depend.

The duration in the egg stage is extremely varied, ranging from as few as four hours in the case of certain Muscidæ to commonly two or three days, or as many weeks. There are cases in which the winter is passed in the egg stage; or, most remarkable, where an entire year and a second winter of dormancy may be followed by successful hatching, as in certain mosquitoes.

As a rule, a considerable number of eggs are developed, but this varies even in a single family like the Tipulidæ from 45 to 2,000. Other species which are reputed to lay large numbers of eggs are certain Simuliidæ, Cyrtidæ, Trypetidæ, Muscidæ, and Tabanidæ. From the data I have noted it would seem that the average number of eggs per female is between 100 and 200.

THE LARVA.

The larval stage of the Diptera shows extreme specialization, being further removed from the typical arthropod condition than any other order. In the majority of the families this stage is a somewhat degenerated one and in many of them extremely so. True thoracic legs are always wanting and only rarely are pro-leg-like structures present. A definite head with well developed mouth parts and sensory organs is wanting in all the higher families. The condition of the spiracles also shows

great reduction, frequently only an anterior pair and a posterior pair or group remaining.

The moults seem commonly to be three in number. The exuviæ are not as a rule prominent and often are entirely inconspicuous.

Organs especially adapting the larva to its environment are frequently noted. Curious suckers and pads for clinging to the surface of rocks in swift streams are exhibited by the Simuliidæ, Blepharoceridæ, etc. Peculiar stellate hairs for increasing surface tension are shown by *Anopheles*. One of the most interesting structures is the well known "rat-tail" or telescopic, posterior, breathing tube of certain Syrphidæ and Ephydridæ, which enables its possessor to feed from one to several inches under the water, while breathing air from the surface.

The majority of dipterous larvæ are aerial in respiration; Blepharoceridæ and Simuliidæ have tracheal or blood gills; while certain Psychodidæ have both open spiracles and functional gills; and the culicid larvæ accomplish respiration in part by spiracles, by gills, through the integument and per rectum.

Dipterous larvæ inhabit well-nigh every accessible haunt on the globe and feed on organic matter in every possible form.

Many are aquatic—Culicidæ, Simuliidæ, Blepharoceridæ and in part the Tipulidæ, Dixidæ, Chironomidæ, Rhyphidæ, Leptidæ, Stratiomyidæ, Tabanidæ, Ephydridæ, Sciomyzidæ, etc. Some of them prefer the clearest and swiftest of streams, others frequent open still water, some stagnant pools and some the foulest of liquids. In fact, practically every condition of water is utilized by some species of the single family Culicidæ. Certain chironomids are said to exist at depths of 1,000 feet.

The food of these aquatic larvæ is very varied and there is a definite correlation between the nature of the food and the specialization of head and mouth parts. Some devour microorganisms, others small plants, as algæ, others small animals and some doubtless the decaying organic materials themselves. Many species live in the soil, especially in moist soil or mud. Their food is either other small animals (Tabanidæ), or the decaying organic matter which contaminates the mud (Syrphidæ), or the roots and tissues of plants (Tipulidæ).

A host of species are found in decaying vegetable or animal matter in every possible stage of disintegration (Psychodidæ, Muscidæ, Drosophilidæ, Bibionidæ, Mydaidæ, Asilidæ, Heteroneuridæ, etc.) We have all marveled at the adaptations which enable an ephidrid fly to live as a larva in pools of crude petroleum, a substance highly toxic to almost all insect life.*

Compared with the Coleoptera, Lepidoptera, Hemiptera, and Orthoptera, Dipterous larvæ are rarely phytophagous on living plants. There are comparatively few crop pests. Yet many are leaf-miners, a good many feed in fruits, seeds, etc., a number are borers in the cambium and other parts of the trunks and stems and some feed exposed on the surface. The Cecidomyidæ or Itonididæ are almost exclusively phytophagous and exhibit the most remarkable and intricate and inexplicable adaptations to the abnormal plant structures they occasion and to securing food.

The larvæ of many Tabanidæ, Syrphidæ and Asilidæ are predaceous on insects and other small animals. Certain leptid larvæ are said to construct conical pitfalls for ensnaring prey, after the manner of ant-lions.

Many species of the Bombyliidæ, Phoridæ, Pipunculidæ, Conopidæ, Cordyluridæ, Sarcophagidæ and Tachinidæ are parasitic on other insects. A few are parasitic on warm-blooded animals, the Hippoboscidæ as ectoparasites, the Oestridæ and in part the Muscidæ, Sarcophagidæ and Syrphidæ as endoparasites. Certain species of the Muscidæ are unique in having larvæ which are intermittent blood-suckers on mammals and birds.

THE PUPA.

One of the most noteworthy features of this order is the clever manner in which the last larval exuvium is utilized as a protection for the pupa stage. Cases aside from the Diptera may be cited where the larva retains its exuvia, more or less mixed with excrement, as a covering during the quiescent transformation period, but I know of none which approach the diptera in the perfection of this habit.

In the suborder Cyclorrhapha entirely and in many of the Orthorrhapha the last molt is not cast at all, but becomes

*See Crawford, D. L., The Petroleum Fly in California. *In* Pomona Col. Jour. Ent. IV, 2, May, 1912, pp. 687-697.

inflated and indurated around the pupal membrane to form a complete, waterproof and resistant box within which the pupa stage is secure. A pair of thoracic spiracles is projected through this puparium for the respiration of the pupa. Quite as unique is the adaptation by which, in several dozen families, an inflatable sac, the ptilinum, is projected through the frons to dislodge the cap from the puparium and permit egress of the fly. So far as it is possible to formulate rules, it is the rule for the pupa stage to be passed in or near the larval habitat. In the case of aquatic or semi-aquatic larvæ the pupa is found in drier situations nearby. It is adapted to float on the water in the Psychodidæ, Chironomidæ, Stratiomyidæ and Ephydridæ. It may even survive successfully on the bottom of pools (Chironomidæ), or under water in streams or lakes, as in certain Simuliidæ, Blepharoceridæ and Ephydridæ.

In the case of the parasitic species the pupa may remain in the host (Conopidæ) or leave the host and seek protection on the ground (Tachinidæ and Oestridæ). In the ectoparasitic Hippoboscidæ this stage may be glued to the hairs or feathers of the host or lie on the ground.

As to the duration in the pupa stage we note the same variation as for the other stages. As a rule this stage is a rather short one, exceptionally occupying only a few hours, and commonly from a few days to a few weeks. But it is very often utilized as a hibernating stage, and in remarkable cases a second winter may be passed in this condition (Trypetidæ). This tendency of part of the brood to be delayed over an entire additional year as exhibited by the eggs of certain mosquitoes and the puparia of some fruit flies is a most inexplicable adaptation for the preservation of the species.

The exact length of the pupa stage is seldom recorded because of the fact that a prepupal stage of most irregular length may occur after the puparium becomes indurated before the change from larva to pupa takes place.

In the matter of activity of the pupa certain families of the Diptera are remarkable. The mosquito pupa swims about actively and avoids enemies in a manner most remarkable for a stage traditionally quiescent.

THE ADULT.

The adult stage is usually short lived, but is quite variable in the different families, and may even vary greatly in the same species, depending on the success of mating, feeding, etc. It is believed that in some species (Culicidæ, Oestridæ, etc.) the adults normally live only a few days and many forms probably never feed. Others lead a very active and vigorous life for some weeks or months as Trypetidæ, Drosophilidæ, Anthomyidæ, Muscidæ, Tachinidæ, Hippoboscidæ, etc. Certain adults have been kept alive well over a year.

Their haunts are almost as varied as those of the larvæ. Two conditions are especially favored:

(a) The vicinity of water in which the immature live. Here are found many Tipulidæ, Dixidæ, Chironomidæ, Blepharoceridæ, Ephydridæ, Cordyluridæ.

(b) Sunlight, which is especially effective on the activities of Tabanidæ, Syrphidæ, Bombyliidæ, Conopidæ and others.

The location of their own food is of course a dominating factor. The most noteworthy point regarding the food of adults is the complete specialization away from the primitive habit of defoliating plants. A very great number of species secure their food from flowers. The Tipulidæ, Culicidæ, Stratiomyidæ, Tabanidæ, Bombyliidæ, Syrphidæ, Conopidæ, Anthomyidæ, Muscidæ and Tachinidæ, are generally flower-feeders on nectar, or pollen, or both. Many species can feed on liquid organic matter or dissolve solid substances and sponge them up.

Species of the families Blepharoceridæ, Leptidæ, Asilidæ, Therevidæ, etc., are predaceous on small insects. In two families, the Tabanidæ and Simuliidæ, almost without exception, the females suck the blood of warm-blooded animals. Six other families are known to contain blood-sucking species—the Culicidæ, Chironomidæ, Psychodidæ, Muscidæ, Leptidæ and Hippoboscidæ. In only one family, the Muscidæ, do we find blood-sucking males, the males of the other families generally feeding on pollen, nectar, etc. Some of the Muscidæ feed on blood drawn by other insects (not being capable of drawing blood themselves) by inserting their proboscides at the side of those of their piercing relatives. A curious habit is recorded

among the Hippoboscidæ, of individuals puncturing flies of their own kind and sucking the blood which the latter are drawing from the warm-blooded host. It is said that chains of these flies three or four individuals long may be found, taking the blood successively from their more fortunately (or unfortunately!) situated associates. The Hippoboscidæ are unique among permanent ectoparasites in possessing wings.

Blood appears to be especially effective on the development of the eggs. For example in certain Muscidæ several feedings of blood are necessary for the development of each batch of eggs. It is said that *Aedes calopus*, after feeding the first time, lays eggs and then becomes nocturnal in habit.

The mouth-parts of the adults, like those of many of the larvæ, are extremely specialized away from the ancestral condition. Within the family, however, they are, superficially at least, rather homogeneous; the species adapted for feeding in the several ways are hardly as diverse in structure as one would expect. The mouth-parts of the blood-sucking Muscidæ are probably unique among piercing insects in having the labium specialized as the cutting apparatus and adapted to enter the wound. The proboscis is rarely extremely elongated, an Indian tabanid having a beak an inch and a half long and three times the body length; this is probably used in probing flowers.

The number of generations a year varies in the Diptera from one, as in Oestridæ, certain Tipulidæ, Syrphidæ, etc., to two or three, which would seem to be the most common condition, (Tabanidæ, Cecidomyidæ, Sepsidæ, Syrphidæ, Trypetidæ, Anthomyidæ, etc.), to 7 or 8 in certain Muscidæ, 8 or 10 in some Trypetidæ, Simuliidæ and Culicidæ, and as many as 20 in Drosophilidæ.

The number is determined (1) by a certain inherent *minimum* time for each stage in each species and (2) by environmental conditions of heat, moisture, food, etc.

It may be said that the dipterous life cycle is noteworthy for *its shortness in certain species*, rather than for any remarkable prolongation or slowness of development. The shortest complete generation is about 10 days for the house fly, fruit fly, etc. while a duration of more than one year is very unusual.

The method of passing the winter is an interesting problem, but unfortunately one on which we have little information.

Any one of the stages may be adapted for hibernation; perhaps more often the pupa, then larva, adult and egg in the order named.

There are many curious mating habits among the Diptera. A common habit is to pair while dancing in swarms. In several cases the males emerge a little earlier and then await the emergence of the females, as in Simuliidæ and Tipulidæ. Indeed, the tipulid male is said to assist the female from the puparium. Oestrid males await about the host animal for the approach of the females. Secondary sexual ornaments of dolichopodid males are displayed before the females; while certain Empididæ construct frothy balloons to attract the females. In the Syrphidæ I have noted mating while hovering, (both facing the same way, male uppermost), and while resting on leaves, facing in opposite directions. In the latter case it may continue uninterruptedly for two or three days (*Temnostoma* spp.)

In methods of reproduction we find a very great range. Parthenogenesis seems not to have been developed in this order. Ordinarily, fertilized eggs are laid in the usual way. The Sarcophagidæ are all larviparous or ovoviviparous. The eggs hatch *in utero* and the active larvæ are extruded, in this family often being attached to a grasshopper or other host while both insects are in flight. The number of offspring per female in this family appears to be very high.

In the *Glossina* and Hippoboscidæ we find a remarkable condition, analogous to the vivipary in mammals, in that the larvæ derive all the nourishment for their growth and development from special glands in the uterus of the female. This, of course, reduces greatly the potential number of offspring; there are only six or eight per generation in the sheep tick.

Another remarkable condition known as paedogenesis is described for Miastor of the Cecidomyidæ. It is said that eggs are produced in ovary-like organs of the larva. These hatch and the young larvæ remain in the abdominal cavity feeding on larval parent tissues until they finally escape. A series of such multiplications is followed by pupation and a normal sexual reproduction of adults. The pupa of a species of *Chironomus* also reproduced parthenogenetically, according to Grimm.

8. HYMENOPTERA.*

By T. D. A. Cockerell, University of Colorado.

In discussing the life history of the Hymenoptera, we naturally turn more especially to those problems which center about metamorphosis on the one hand, and parasitism on the other. My work on fossil insects has caused me to speculate on the origin of these habits and characteristics, without enabling me to reach any definite conclusion. To many, these speculations will doubtless seem rather futile, yet no intelligent person travels a road without some thoughts about his journey's end. Hypotheses not only quicken the imagination, but at once increase the significance of every scrap of information which tells for or against the opinions one has formed. Thus the discovery of a fragment in some ancient rock becomes a dramatic event.

Overlooking the town of Boulder is a hill from which one can look north across the flank of the front range. A series of red rocks, now standing on edge, once formed the shore of the Upper Carboniferous sea. A narrow valley separates these from another sharp ridge, belonging to the lower part of the Upper Cretaceous. It is interesting to look at these strata and realize that in the interval between the first and the second, the typical flowering plants, the birds, the mammals and the insects with complete metamorphosis all came into existence. Were these striking events accidentally coincident, or was there some causal connection between them? The sea was the mother of life and the land was discovered, so to speak, by successive types of organisms. During the Carboniferous, the terrestrial arthropods, especially the insects, were abundant and often of immense size. The Amphibians represented an invasion of the vertebrates, doubtless preying upon the rich insect fauna. Reptiles, with hard-shelled eggs, finally solved for the vertebrates the problem of completely terrestrial existance. Birds and mammals must have owed the possibility

*I took part in the symposium as a substitute for another, to whom the topic had first been assigned. I prepared no manuscript, and indeed have no special knowledge of the matters which I should have discussed. It has not seemed worth while to compile a summary from the literature, in order to secure approximate uniformity of treatment.

of development largely to the abundance of insect life. Thus the insects, at first comparatively immune from attack, were hard pressed by enemies on the ground, in the trees and even in the air. The larger, more conspicuous types disappeared, giving place to a great variety of rather small forms, which could easily be concealed, or were perhaps in some cases, extremely prolific. In the meantime the increasing diversification of the flora, with the development of many kinds of woody plants, afforded new opportunities for specialization. The advantages of metamorphosis under these conditions are obvious and no one can doubt that several distinct types of larva began to diverge from the primitive orthopteroid condition, in the soil, in the water, and within the tissues of plants. It thus seems to me probable that the primitive Hymenopteron did not possess a caterpillar-like larva, but a boring one, in the manner of the existing Siricoidea. Such a larva would be in a position to take advantage of the newer types of vegetation, and at the same time avoid to a large extent the attacks of vertebrate enemies. The birds of those days had teeth, and the bill as a boring organ, such as we find in the woodpecker, had not developed. This view is supported by the only well-known Mesozoic Hymenoptera, the Pseudosiricidæ. These large insects, as I have lately shown, survived into the Eocene, but are now extinct. They possessed what is to be regarded as a stout ovipositor, probably derived from an orthopteroid ancestor. Their venation does not lend any support to the idea that the basal nervure is a cross-vein; it should rather be a branch of the cubitus fusing distally with the media. From such a type, it is not difficult to derive on the one hand the Ichneumonoid parasites, and on the other the ants. The resemblance of the venation of the Pseudosiricidæ to that of the ants is so striking that they were once regarded as gigantic ants. Just as the New Zealand parrot, from feeding on vegetation, has taken to attacking sheep; so the early Hymenoptera, successful as borers in wood, may have taken to boring in various larvæ, securing thereby more elaborated, more concentrated nourishment for their young. The ants, on the other hand, met the problems of life in another way, by developing community organization. The ant larva is a highly specialized being, which has to be fed by the adult. Is there not reason to suppose that it was originally self-supporting, and was therefore in pre-ant times a borer in

vegetable tissue? That it fed externally in the manner of a modern sawfly seems in the highest degree improbable.

It is obvious that parasitism has arisen over and over again among the Hymenoptera, as Wheeler* has recently shown in some detail. The parasitic aculeata have nothing to do with the Ichneumonoidea or Chalcidoidea, and the inception of their parasitic habits was entirely different. Among the bees, the extraordinary case of *Androgynella* is very suggestive.† This type, of which two species are known, is a *Megachile* in which the ventral scopa is wholly lacking in the female, which has 13-jointed antennæ and spined anterior coxæ, as in a male, but still retains the sting. In the light of modern genetics, we can form some idea of the origin of such a condition, but that it should be able to survive is surprising. It could survive only by becoming a guest or parasite of the other or normal bees, and this is evidently what has taken place. Thus parasitism among bees may owe its origin to a species of necessity, confronting insects which no longer possessed the power to function in the ordinary way. Among the Ichneumonoidea it was rather the development of an advantage, leading to a great increase in the number of genera, species and individuals. The parasitic aculeata have never been dominant like the ichneumons; they are mostly comparatively rare or sporadic in their occurrence.

These considerations suggest interesting possibilities of experiment. How far is it possible to modify the reactions of insects by changing their conditions of life? But when the modification is internal, is due to some alteration of the germ-plasm, it may well affect instincts as well as structure. Modern breeding, such as that of *Drosophila*, has revealed the fact that, at least in certain insects, mutations are relatively frequent. In nature, no doubt, the vast majority perish, but an occasional one survives and enters upon a new course of life. Thus a process which is detrimental to many individuals, is advantageous to the group, being in the long run a potent cause of specific and generic differentiation. The outcome is diversity of adaptation, purposeful in the sense that the existing powers of variation and response are capable of leading to the results we see.

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*Proc. Amer. Philosophical Society, LVIII (1919), pp. 1-40.

†For details, see Philippine Journal of Science, XIII, D. 4 (1918), p. 140.

9. THE LIFE CYCLE OF INSECTS; GENERAL DISCUSSION.

Stephen A. Forbes, Chief, Natural History Survey of Illinois.

In preparing for a general discussion of so large and complex a subject as that of this symposium, two choices were open to me. For one, I might have tried to summarize, generalize, and reduce to fundamental principles as well as I could on the spur of the moment the data and inferences presented by the specialists who have entertained and instructed us by their remarks on the life cycles of the various orders in which they have specialized. The alternative choice was a presentation and brief discussion of a limited number of topics, too general to come within the divisions of our subject treated by my predecessors on this program, and of kinds to which, in my judgment, we ordinarily give too little attention. Whether rightly or wrongly, I have made this second choice, with the idea especially of pointing out deficiencies in our knowledge by way of suggestion to the younger entomologists who are in the line of succession to the problems which we of the passing generation have solved imperfectly, mistakenly, or not at all.

One of the most fundamental features of the life history of insects, with its innumerable variations more or less adaptive in character, is the necessary inference that all these fixed differences are predetermined in the protoplasmic composition and structure of the fertilized egg, each succeeding step in any life history following upon the preceding one by a physical necessity; and the further fact that in each order of insects—each insect species, indeed—this minute, invisible, and possibly indeterminable structure of the protoplasmic egg must have been passed down by inheritance virtually unchanged from an extremely remote ancestry. On the other hand, all the variations and differentiations which have arisen to distinguish species from species, family from family, order from order, in respect to the general course and the minor details of their life histories, must have made their appearance as variations and differentiations in the egg protoplasm, which exhibits at once a constancy in some lines and an instability in others which, taken together, have made evolution possible. This *constancy*

we see illustrated by the fact that the average course of the life cycle in any insect species is virtually uniform so long as the external conditions affecting it are uniform. The average lengths of the egg, larva, pupa, and imago stages of a holometabalous species are the same in any given locality, season after season, if the seasons average alike in temperature, humidity, etc.; but the *instability*, nevertheless, of this same protoplasm is shown by the fact that individual variations in the details of life history appear among insects of the same species and variety, hatched from eggs laid on the same day, and kept continuously under identical conditions. In Doctor Shelford's unpublished experiments, pupæ of the codling-moth, formed on the same day from the same lot of larvæ and kept side by side under the same conditions until the imagoes emerged, have had pupal periods of 9½ days, 10½ days, and 12½ days in one series, and in another series of 10½ days, 11 days, 11½ days, 12½ days, and 13½ days, and so on; and another colleague, Mr. P. A. Glenn, tells me of 24 codling-moth pupæ formed on the same day and treated precisely alike, of which one gave the imago in 8 days, six gave imagoes in 9 days, ten in 10 days, six in 11 days, and one in 12 days. Still more significant are some of his data concerning the incubation periods of the *eggs* of the codling-moth, these varying from 12 to 15 days for a lot of 46 eggs laid May 5, from 8 to 10 days for 162 eggs laid June 3, and from 8 to 11 days for 118 eggs laid June 5, all being kept under like conditions. He has had, indeed, occasional instances of single larvæ of the first spring generation surviving as pupæ until the following spring, representing thus a one-generation variety of the codling-moth, although their brothers and sisters took the usual course of two or three generations in the year.

These individual differences in the sensitiveness of the egg protoplasm to the stimuli of development furnish, *if they are heritable*, abundant materials for the action of natural selection in fitting a species more exactly to its environment in respect to its life history, just as other kinds of variation make possible an improvement of its structural adaptations; and a study of these variations in life history, of their continued heritability, and of their advantages and disadvantages to a species by way of its adaptation to the various environments in which it is found, is just as necessary to a knowledge of our subject as is the

corresponding study of visible variations of structure to a knowledge of the phylogeny of the insect organism.

One of the environmental conditions to which an insect may adjust itself by reason of this flexibility of its life history is its relation to its food-plant and to its competitors for food. Remembering that the prosperity of a plant-feeding insect is dependent on the abundance and continued growth of its food-plant, and that this plant, for its own best prosperity, must produce for its insect guests timely supplies in quantities which can be spared without actual injury to the plant itself, we see a mutual advantage to insect and plant alike if the draft on the growing plant shall be distributed over as long an interval as possible, in order that the product of continuous growth may go as far as possible to supply the demand. Obviously, the demand of a thousand insects delivered in one day might effectually bankrupt a plant which could honor the draft without embarrassment if it were distributed over a fortnight or a month; and this advantage to the food-plant would react, of course, to the advantage of the feeding insect also. There is thus a standing reward offered to every insect dependent for food on a living and growing organism, for establishing and maintaining an individual variability in its sensitiveness to stimuli such as shall lengthen the period of its depredation.

Of course, individual differences in the rate and the period of development of the insects of the same generation, and even of the same parentage, are not all due to variations traceable to the egg, but many are consequences of different individual exposures to stimulating or retarding factors; as a consequence of them all, (some original and some incidental), the effect of an infestation is diluted and diminished by an extension of its period, to the common advantage of the infesting guest and the infested host.

Furthermore, it seems possible that this depredation period may be shifted as a whole, so as to come earlier or later in the season, if competition with another species of kindred habit may be thereby evaded. If two species infest a food-plant at the same period, their joint number must be so limited, as a general rule, that their attack will not destroy the food-producing plant; but if they can come to succeed each other so that each shall have the plant for a time to itself, both may maintain a higher rate of multiplication without permanent

injury to their common host; and individual variations in the length of the stages of the life cycle already referred to make this easily possible. If there is any initial difference whatever between the competing species as to the period of their attack, natural selection may do the rest, and even if there is not, mutation of habit may have the same effect. I happened, many years ago, upon an apparent instance of this kind, when I was studying the life histories of the so-called root-worms of the strawberry—larvæ of three species of chrysomelid beetles which devour the roots of the plant. One of these larvæ, that of *Colaspis brunnea*, begins its work in southern Illinois in early spring and continues active through June; another (*Typophorus canellus aterrima*) begins in June and continues into August; and the third (*Graphops nebulosus*) begins in August and continues active through the fall, hibernating, in fact, in the larva stage.

It is a significant fact that another species (*Graphops pubescens*) closely allied to the last and with a like distribution, but living on another food-plant, refusing, indeed, the roots of the strawberry and feeding only on those of the wild evening primrose, has a very different life history from its near relative, wintering as an adult instead of a larva, as does the strawberry species. There is here a suggestion of a possible shifting of the life history of the strawberry *Graphops* in a way to adjust its demands for food to those of its competitors. Of course, this seeming adjustment may have been a coincidence merely, and I do not know of another instance of the kind; but, on the other hand, I do not know that such instances have been sought. Most of our best life history work has been done on insects infesting the crop plants, where the natural reactions of plant and insect are so generally disturbed or annulled by the overpowering agency of man that we must look for clear cases of interlocking life histories of competing insects among those dependent on uncultivated plants; and here but little has been done.

The foregoing case may at any rate serve to illustrate the fact that for a full understanding of the adaptations of insects to their environment by way of their life histories, we must not study merely the separate species in their natural habitats, but must make local ecological groups our units for investigation, and inquire into the system of competitions, and adjust-

ments and avoidances of competition, exhibited in their relations to each other. We have much reason to expect, indeed, that an insect association of long standing in a geographical area, or in a set of situations of fairly uniform character, will have come to make many internal readjustments—adaptations of one species to another in habit and life history, of each species, perhaps, to several others, of different stages of the same species each to the other, such that the whole association may avail itself to the best advantage of the resources for existence and multiplication offered to it by any environment. The strains and pressures of competition will thus be in some measure relieved, and an internal equilibrium of the ecological group will be reached which will smooth and steady the system of interactions within the association, to the general advantage of all its members. It seems to me quite possible that a single species of wide range may have become a permanent member of unlike associations in different parts of its area of distribution; may have had to adjust itself, consequently, to different systems of interaction with its associates; may have acquired local peculiarities of life history not to be understood until these internal systems have been studied and made out.

The subject is, indeed, delightfully complex—a challenge to the curiosity and ingenuity of the accomplished naturalist equipped with apparatus for exact experiments with variations of temperature, moisture, light, rates of air movement and evaporation, such that he can produce any desired combination of these natural factors of the insect environment and determine their separate and conjoined effects on the life cycle of any species which he wishes to study in detail.

An equipment of this description is invaluable in testing the inferences of the field observer and in detecting reactions to features of the insect environment which are obscured or lost in the complex of the natural system out-of-doors. By such a means we are beginning to account for some, at least, of the almost explosive outbreaks of insect multiplication in certain species, which we find peculiarly sensitive to meteorological conditions by which others are little affected. Doctor Shelford tells me, for example, as a result of his studies now in progress on the chinch-bug, that these insects, whose numbers fluctuate enormously in successive years, are extremely dependent on relatively high temperatures; that with optimum

humidity, multiplication is very slow and breeding experiments usually fail at a temperature of 70° F. (a much higher limit than that of any other insect studied), but that with high humidity and high but variable temperatures like those of a hot, moist day in summer, breeding experiments are highly successful, and the rate of multiplication is almost unbelievably rapid.

I am beginning to hope that, by vivarium work and companion studies in the field, we shall be able soon to standardize our life history data so that we can describe the life cycles of insects, not primarily in unreliable units of time, so variable as to be perplexing, but in ecological units of temperature, humidity and the like, invariable for a species whenever and wherever it may be found. An example of such a standardization is furnished by the product of recent work on the life cycle of the codling-moth done by Mr. Glenn at a well-equipped orchard station in southern Illinois, to the effect that in normal seasons, when the sum of all mean daily temperatures which fall between 50° and 85° F. reaches 550°, the eggs of the spring generation of the moths will begin to hatch, and when these totals reach 1550° those of the second generation will hatch, and when eleven hundred degrees is added to this sum, the third generation may begin to hatch; but that if this last total of 2650° is not reached before September 10, there will be no third generation at all in that year; and these statements may be expected to hold good every year without regard to the character of the season or to differences of elevation or latitude. Dr. Shelford is now working out in the vivarium a scheme of corrections to be applied to this forecast whenever the humidity factor is practically important.

Our present method of describing life histories in days or hours for each stage or phase is, indeed, thoroughly illogical, for mere lapse of time has, of course, no effect in itself; it is only the dynamic content or accompaniment of the time unit, especially in temperature and humidity, which really signifies. We must find our unvarying ecological constants and make up our life-history calendars of these and not of the uncertain units of time which we now use simply because they are the most easily obtainable.

Perhaps we shall never know just how and to what immediate profit the holometabola were differentiated, but that the

differentiation was a fortunate one for the future of insect life in the world is shown by the present great predominance of holometabola over ametabola and hemimetabola, and by the obvious advantages which they have in the struggle for existence. By their premature hatching from the egg before the characters of the adult have been laid down in the embryo, their larvæ are much more capable of adaptive modification for their life as larvæ than are young Orthoptera or Hemiptera, already virtually adult at birth, except as to size, sexual organs, and organs of flight. Hence we see, in the vast majority of cases, the holometabolous larva taking its own course in its own interest, quite regardless of the coming necessities of the adult, with the result that larva and adult have widely different ecological relations, belonging, indeed, to different ecological associations, and do not compete with each other in any way. As the closest competitors of an ametabolous insect are the members of its own species, the division of any species into two non-competing groups diminishes by a certain considerable fraction the dangers of this interspecific competition. On the other hand, the fact that the holometabolous insect must alternate between two quite different environments, one for the larva and the other for the adult, makes its failure to find either one a fatal catastrophe, requires the coincidence of two favorable environments, instead of the occurrence of only one, for its survival; but this danger is largely overcome by the remarkable development of instinct which leads the female adult to deposit her eggs at a place and time as favorable as possible to the success of the larva; and in the social insects it is of course much more than compensated by the solicitous care which the young of all stages receive from the mature.

I think we may also count the holometabolous insect as relatively fortunate in respect to its exposure to predaceous enemies, parasites, and contagious diseases. A grasshopper is endangered during its entire life cycle by the same kinds of destructive agencies—the same species of predators (except as it outgrows some of them), the same kinds of insect and other animal parasites, and the same bacterial and other fungous diseases—but white-grubs and May-beetles differ one from the other almost completely in these respects. The attacks of parasites and contagious diseases commonly increase in intensity with the length of time during which their victims are exposed

to them, so that they are much more destructive in the second half of the insect life cycle than in the first; but in a holometabolous insect with unlike larval and adult habits and habitats, this period is divided into two unlike periods of disease or infestation, and there is no second half to either of the two.

The multiplication of seasonal generations in some species is a consequence of a high degree of sensitiveness to temperature and other developmental stimuli; and this may enable a species to push its range into colder latitudes than would otherwise be possible, giving it at the same time a capacity for multiplication in the milder latitudes far in excess of that of its single-brooded competitors and enabling it to take prompt advantage of seasonal conditions temporarily favorable and to rally quickly from the effects of those temporarily injurious. I surmise that the many-brooded species have, as a rule, had an experience of frigid or semi-frigid life—that of a glacial period, for example—during which variations towards a quick physiological sensitiveness to heat stimuli have been selected for survival. Entomologists are but just beginning to determine accurately the so-called physiological zero or threshhold of development of the several insect species, and have accumulated as yet too little precise knowledge of the temperature at which development begins and of the effects of differences of humidity in shifting this zero up or down to enable us to base our surmises on experimental evidence. There is an almost limitless field for interesting investigation open to those who have command of a good experimental equipment, and the entomologist who first carries through a seasonal series of experiments on the army-worm with its three annual generations in comparison with one of the single-brooded noctuids, both kept together under identical conditions for a study of their differences of reaction to ecological factors, will get some new and important results.

As I piece together, after a fashion, these few scraps and fragments of observation, interpretation, and inference which I am offering here, it seems to me that the general pattern which they suggest is that of a wide-ranging, open-minded survey of insect life as it is actually lived by these complex and variable creatures, in constant interaction with the still more complex and similarly variable system of objects and energies which together constitute the insect's world—that we need to

study that world from the insect standpoint as its center, to realize as clearly as we can, by insight and imagination, what it would be to a beetle or a butterfly, a caterpillar or a grub, if it were endowed with our capacities of observation, analysis and inference; how and to what ends and by what means it would act upon that world and how and by what means its world would react upon it in turn; and what has been the history of the system of actions and reactions through the agency of which it has become what it finds itself to be. Except as we can approximate this ideal—in so far, that is, as we adhere in our studies to the merely human point of view—our perspectives must be distorted and our emphases wrongly placed, to the confusion and disappointment of our efforts to solve the intricate problems of insect life.

THE EXTERNAL ANATOMY OF ANTHOMYIA RADICUM Linn.*

(Diptera, Anthomyidæ).

By Howard L. Seamans.

CONTENTS.

The North American Anthomyidæ, though belonging to one of the largest and most important of the families of the Diptera, are nevertheless in very unsatisfactory condition from the systematic standpoint. The permanent work that has been accomplished on these flies has been concerned largely with the economic relationships of individual species, and, in this country at least, very little thorough work along taxonomic or morphological lines has been done. It is apparent that there is a real opportunity for systematic work in this group, and, as a preliminary step in this direction, the writer undertook a morphological study of *Anthomyia radicum* Linnæus, one of our most common species in this family, and this paper gives the results of this study.

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*Contributed from the Entomological Laboratories of Montana State College.

The writer desires to acknowledge his indebtedness to Professor R. A. Cooley and Dr. R. R. Parker for many helpful suggestions.

Specimens for study were first softened in a solution of alcohol, glycerine and formalin. For the study of the wings and legs these parts were removed from softened specimens and placed in 70 per cent alcohol, then in carbolic acid-turpentine clearing solution, and finally mounted in Canada balsam. For the study of the body parts bearing sclerites and sutures it was usually necessary to cut away the parts with a sharp scalpel, boil in a 5 per cent solution of potassium hydroxide to remove non-chitinous tissue, preparatory to mounting in balsam. The head capsule was prepared in the same manner and mounted whole in balsam, in a xylonite ring. Treated in this manner the parts under study retained their normal form, while the bristles, sclerites and regions could be distinctly seen.

Some specimens were placed in chlorine water until they had been bleached to a light yellow and were almost transparent. These were then washed, dehydrated and placed in thin balsam until they were completely filled with the medium. Whole mounts were made in xylonite rings and studied for the various structures.

Drawings were made from prepared slides with the aid of apparatus consisting of a small arc lamp the light of which was directed through the barrel of a microscope placed horizontally with a mirror attached so as to present a surface to the ocular at 45°. When a slide was placed on the stage of the microscope the image was projected on a paper under the mirror on the table where it could be traced.

Anatomical Structure.

The terms used in designating special sclerites, sutures or regions are for the most part those recognized by Dr. Crampton of the Massachusetts Agricultural College. In some instances terminology has been taken from Lowne, or other authentic sources, but since the terms are in common usage, they should cause no confusion.

THE HEAD.

The outline of the head when viewed from the front (Figs. 1 and 2) is nearly circular, being slightly wider than high, and less regular in the female than in the male. Viewed in profile the outlines differ greatly in the two sexes. In the female (Fig. 3) the line from the vertex to the base of the antennæ is almost at right angles to the line from the vertex to the occipital foramen. The face is almost perpendicular, having a slight tendency to be retreating. The antennæ are situated distinctly above the middle and are about one-third as long as the major axis of the head. In the male head (Fig. 4) the vertical angle is decidedly acute, the antennæ are situated at about half way down from the vertex, the face is retreating, making the epistome appear to protrude, and the minor axis is only two-thirds the length of the major axis. The posterior aspect of the head is essentially the same in both sexes, showing distinct sclerites and sutures, while the anterior portion shows regions which are variable in the two sexes. There are five sutures arising from points on the occipital foramen (Fig. 7). Two of these arise from the two dorsal angles of the foramen, two from the two ventral angles, and one from the middle of the dorsal margin. The two sutures arising from the dorsal angles of the foramen are the paracephalic sutures of Lowne (prsu). These extend upward to the vertex and then around the compound eyes. The two lateral halves of the head thus formed are the paracepala (prc) (Fig. 7).

The suture which arises from the middle of the dorsal margin of the occipital foramen extends about one-third the distance towards the vertex and forks, each fork disappearing in a faint, almost indistinguishable suture which turns downward at an acute angle to meet the foramen at the base of the paracephalic sutures. The two triangular areas thus formed are the epi-occipital sclerites of Lowne (epos). The space between the paracephalic sutures and above the epioccipital sclerites is the epicephalon (epc).

The two sutures which start from the ventral angles of the foramen are the basal sutures (bsu). These extend downward, meeting a fold just above the oral margin, and become indistinct. The somewhat irregular six-sided area cut off from the paracephala by these sutures is the metacephalon (mtc). The

vestiture of the occiput shows more or less distinct regions of which one is very clearly defined. This is a region just back of the compound eyes, the posterior eye orbit, set off from the rest by a row of more prominent hairs (Figs. 3, 4 and 7). There is a small patch of fine bristles at the base of each epioccipital sclerite, while the epicephalon is bare, except for the post vertical bristles. The metacephalon is divided into two lateral regions by the vestiture, leaving a groove in the center practically bare.

Viewing the head from the front (Figs. 1 and 2) the most striking difference between the sexes is in the compound eyes. Those of the male are very large, being practically contiguous for a short distance, while in the female they are smaller and widely separated. The antennæ of the female are located higher up than are those of the male, and the vertical bristles are much larger. Except for a considerable narrowing in the male the regions in both sexes are homologous. The male head bears more bristles than the female but they are weaker and less prominent.

At the extreme vertex of the head in both sexes there is a heavily chitinized, slightly raised, almost equilateral triangle, with its apex directed towards the base of the antennæ. This is the ocellar triangle (ot) and it bears a simple eye in each corner. It bears three or four pairs of stout short bristles, the posterior ones upright, and the anterior ones directed forward. Below the ocellar triangle and above the base of the antennæ is a region known as the front. In the males this is a triangle with the apex directed upward and is known as the frontal triangle (ft.) (Fig. 2). In the females the front (f) is broad, somewhat rectangular, bears a pair of bristles located just below the ocellar triangle, and directed forward, the cruciate bristles. In the male these two bristles are located very close together at the apex of the frontal triangle.

The vertex in the female bears two pairs of large vertical cephalic bristles, the inner pair convergent and the outer pair divergent. Behind the ocellar triangle is a pair of divergent post vertical bristles.

On each side of the front, bordering the compound eyes, is a narrow region which reaches from the vertex to the base of the antennæ, where it is cut off by an oblique division line. These two areas are the parafrontal plates (prf) bearing eight pairs of

bristles in the female, and ten in the male, the fronto-orbital bristles (fobr). Below the parafrontal plates are narrow regions which follow the orbit posteriorly. These regions are the genæ (g) and bear no bristles or spines (Figs. 1, 2, 3, 4), but are sometimes pubescent.

At the base of the front and just above the base of the antennæ, is a triangular opening lunule (l) through which an eversible sac, the ptilinum, protrudes when the insect is emerging from the pupa. From this opening a suture extends downward on each side, ending just below the tip of the third joint of the antennæ. The eversible sac extends the entire length of the suture. This suture is the frontal suture (fsu) of Lowne, and a slight line of demarkation extends from the tip of the suture to the oral margin. The lower margin of the lunule is formed by the upper margin of the sclerite which bears the antennæ. (Fig. 5). The sclerite is cut off from the head capsule by a suture, for the most part concealed by the antennæ. This suture, however, follows the vibrissal ridge, below the antennæ, and then encircles the oral margin. The sclerite shows distinct regions including the epistome, though no bristles are present, and corresponds closely to the face, as that term is used by Lowne. However, Lowne includes in his term face all the area surrounded by the frontal suture. The area which Lowne considers the facialia or facial edge of the paracephalon is the region which in this species lies between the face and the frontal suture and bears the oral vibrissæ and facial bristles. (Figs. 1, 2, 3 and 4).

Between the genæ and facialia is a somewhat flattened, triangular area extending from the oral margin to the eye border. This is the transverse impression or bucca (bu) and in both sexes is devoid of bristles or hairs, but is somewhat pollenous. (Figs. 1, 2, 3 and 4). Bounding the bucca posteriorly and extending towards the occiput and along the oral margin is a distinctly raised or convex region, which is the cheek (c). This is covered with long black hairs and has a row of distinct bristles along the oral margin. (Fig. 1, 2, 3, 4).

The antennæ present no distinct sexual differences. (Fig. 6). They are three jointed, the third joint bearing a long, slender, pubescent, three-jointed arista (ar). The first joint of the antenna is the smallest, short, collar-like and slightly compressed laterally. There are two bristles on the anterior

surface. This joint appears to be immovably attached to the head. The second joint is longer, attached to the first by a movable joining, and bears a coronet of bristles on its anterior surface. The third joint is the largest, being twice as long as the second, somewhat broader, and laterally compressed. It is attached to the second joint by an immovable attachment formed by parts fitting together like saw teeth. In addition to the three jointed arista, this joint bears structures which are apparently sense organs, consisting of openings leading to small internal cavities. Each such opening is protected by a ring of bristles pointing outward towards a common center. This joint also appears to be porous and sponge-like, the pores being much smaller than the openings to the sense organs. All three points are covered with short, fine pubescence.

The arista (Fig. 8) is three jointed, all the joints movable, and pubescent. The first two joints are short, cylindrical, the second about twice as long as the first. The third joint is long, somewhat larger at the base and for the basal third, tapering from there to a fine hair-like point. The spines appear to be different from ordinary spines and may function as sensory hairs.

The discussion of the mouth parts will be left for a later publication as they appear to show no characters of value to this work, but do show some interesting anatomical features that need further study.

THE THORAX.

Of the thoracic segments, the first and last are greatly reduced, the mesothorax forming the greater part of the whole. The dorsum of the thorax, with the exception of the two anterior swellings, is the mesonotum. The two anterior swellings or the humeral callosities (hcly) are the upper portions of the pronotum. (Figs. 10 and 12). Anterior to the base of the wings a suture crosses the mesonotum, the transverse suture (trsu), which separates the anterior region or prasecutum (prs) from a posterior region, the scutum (sc). Above the halteres another suture crosses the mesonotum separating the scutum from a posterior, somewhat triangular region, the scutellum (scl). (Figs. 9 and 12). The mesonotum bears two distinct rows of large, strong bristles which diverge slightly posteriorly (Fig. 9). Each row consists of five bristles arranged two on

the praescutum, and three on the scutum. These are the dorsocentral bristles, those on the praescutum being the anterior dorsocentrals, and those on the scutum being the posterior dorsocentrals. Between the rows of dorsocentral bristles are two rows of setæ, never very symmetrical, variable in number, starting with two strong bristles on the praescutum and ending in two strong bristles at the posterior end of the scutum. These are the acrostichal bristles (acr). Two strong bristles are present on the humeral callosities, which are known as the humeral bristles (hb). (Figs. 9, 10 and 12). On each side of the praescutum, close to the humeral callosities, is located a strong bristle, the posthumeral bristle (phm.) Near the posterior angle of the praescutum there is a strong bristle, the praesutural bristle (prsl). On the sides of the praescutum, next to the notopleural suture there are two strong bristles, the notopleural bristles (npl). (Fig. 12).

In addition to the bristles mentioned above, the scutum bears two bristles outside of each row of dorsocentral bristles, the intra-alar bristles (ial). Below and somewhat anterior to the intra-alar bristles, on the sides of the scutum, are located the supra-alar bristles (sal). In some of the Anthomyidae there are three supra-alar bristles, the anterior one being the "Pro" of Stein. Posterior to these and located on the side and dorsum of the postalar callosities, are the post-alar bristles. (pal).

The bristles of the scutellum are small except for one pair of strong bristles located at the anterior angles of the scutellum, and a pair of still larger ones, located on the posterior border of the apex. This last pair have been called the apical bristles or scutellar apicals (scla).

The prothorax is indistinct when viewed from the side, being represented by three visible sclerites. Of these three, the pronotal lobe, or humeral callosity, is the most conspicuous (Fig. 12). This is an irregularly shaped sclerite somewhat resembling a budding mushroom in general outline. The two humeral bristles (hm) are located on this sclerite, near the dorsal margin. Below this sclerite, and separated from it by a distinct suture, is the proepisternum (pres). This is also irregularly shaped and bears three bristles near its ventral margin, just above the base of the prothoracic coxa. Anterior to these two sclerites another sclerite can be noticed in a lateral view. This is the prodorsum (pd) of Lowne, but it can be better studied in an anterior view.

The anterior view of the prothorax (Fig. 10) shows the parts before mentioned. The prodorsum forms the dorsal rim of the foramen and an articulation with the head. At the two lower angles of the foramen are triangular sclerites, which have anterior projections. These are the condyles (cnd) of Lowne and also articulate with the head. Between the condyles is a rounded somewhat shield-shaped sclerite, which Lowne has termed the sella (s). This articulates with the lower part of the occipital foramen of the head.

Below the sella and condyles and between the coxa (cx) the prosternum (psn) is seen as a somewhat shield-shaped sclerite, but extends posteriorly to meet the sternopleurite. A study of the pleura of the thorax shows many sclerites and sutures of the other thoracic segments (Fig. 12).

Posterior to the propleura and below the præscutum is a large, irregular-shaped sclerite, the largest of the pleural sclerites, which is separated from the posterior portion of the mesopleura by a strong suture, the pleural suture (plsu). This suture, arising from the base of the wing, extends irregularly to the middle coxæ. The sclerite formed by this suture is made up of the mesoepisternum fused with part of the sternum and pro-epimeron. The sterno pleural suture (ssu) imperfectly divides this sclerite dorso-ventrally, the dorsal portion being the anepisternum (ans) and the ventral portion the sternopleurite (stp). In the upper anterior corner of the anepisternum is located the anterior spiracle (spa) (Figs. 10 and 12). Behind the upper portion of the pleural suture is an irregularly pentagonal sclerite, which has a short suture starting into it from the dorsal border near the wing base. This suture indicates the fusion of two sclerites, the anterior one being the pleural wing process (pwp) and the posterior one the ptero-pleurite (ptp). Below the ptero-pleurite and behind the lower section of the pleural suture is located another irregular five-sided sclerite which is divided by two faint sutures into three parts. The whole sclerite is known as the mero-pleurite and forms the posterior ventral sclerite of the mesothorax. The posterior dorsal sclerite of the mesothorax is located in front of the halteres, and divided into two portions by a slight transverse suture. This sclerite extends to the anterior portion of the scutellum, and is known as the pleurotergite (ptg).

Immediately below the scutellum is an exceedingly convex sclerite, part of the post-scutellum, which extends laterally to the pleurotergite, and is known as the mediotergite (mdtg). Below the mediotergite is a sclerite which bears the halteres, the metanotum (mtn). Back of the meropleurite is a long, slender sclerite in an oblique position, the metaepisternum, which is divided at the upper end by a suture making two divisions in it. Below the metanotum and posterior to the metaepisternum is a sclerite of similar shape, the meta-epimeron (mtem) (Fig. 12). Surrounded by the metaepisternum, the pleurotergite and the meropleurite is the posterior spiracle (spp) (Fig. 17).

There are membranous portions of the thorax near the base of the wings, which allow freedom of movement of parts. There are four small plates or sclerites in this membranous portion, two at the base of the wings, and two posterior and above the ptero-pleurite. The first two are the basal plates (bpl) and the latter are the sub-alar plates (sapl). Above the sub-alar plates is a triangular, more or less distinct, region extending towards the scutellum, known as the juxtascutellum or scutellar bridge. (jscl).

The chaetotaxy of the pleura is similar in both sexes with the exception of the sternopleurite. The anepisternum has four stout bristles near its posterior margin and a more or less covering of hair. In the male, the sternopleurite has one strong bristle below the sternopleural suture, one at the posterior angle of the pleural suture, and one just below the last, also along the pleural suture. (Fig. 12). In the females the last mentioned bristle is wanting. In both sexes the sternopleurite has two (more or less strong) bristles on the anterior surface just above the front coxæ, and is somewhat covered with hair on the posterior portion, which become bristles just in front of the mesocoxæ. The coxal sclerite next to the sternopleurite has a row of four strong bristles.

Each spiracle is surrounded by fine hairs which curve over the openings and serve as a protection or sieve.

THORACIC APPENDAGES.

The wings show no difference of structure in the two sexes. (Fig. 13). The costal vein extends to the tip of the fourth vein, and is weakly pectinate. At the tip of the auxiliary vein, the costa is broken, and a short, weak spine is located at the basal

side of the break. The first vein (v1) ends in the costa at about the center of the anterior margin. The second vein (v2) ends by a short, but distinct, curve forward in the costa near the tip of the wing. The third vein (v3) ends at the tip of the wing with a slight curve forward, while the fourth vein, ends either straight or with a slight convergence from the third vein. The anterior cross (acrv) vein meets the margin of the discal cell (dcl) at the distal third, and almost at right angles to the third vein. The posterior cross vein (pcrv) is oblique, meeting the fifth vein about one-fifth of the distance from the wing margin. The second basal (bcl2) and anal (acl) cells are of equal size and small. The alula (ala) is slightly smaller in the female wing than in the male, but conspicuous in both sexes.

At the base of the costal vein there are two scales (Figs. 13 and 14) which have been called the tegulæ, or epaulets. These lie over the base of the vein, the uppermost one being the tegula or epaulet (ept) and the lower one the sub-tegula or sub-epaulet (sept). These are of some use in the classification of some flies and could probably be used in the Anthomyidæ.

The base of the first vein seems to be in three sections. The first two of these have several small openings (Figs. 13 and 15). According to Lowne, these openings, especially the group on the remigium (rm), or first section of the vein, are the chordonotol organs, the same as are found more highly developed in the haltere. Similar openings are also found on the auxiliary vein, at the tip of the first vein, at the tip of the second vein, at the tip of the fifth vein, and on the anterior cross vein (Fig. 13). The membranous portion of the wing is covered with fine spines as are also the veins. The border of the wing has a short fringe of fine hairs.

The squamæ (Fig. 16) are two membranous scales located at the base of and below the wings. When the wing is pulled forward the two scales are plainly seen, the upper or antisquama (sqa) being the anterior and the squama (sq) or lower one, the posterior scale. In this species the antisquama is larger than the squama and round, while the latter is roughly triangular. There is a fringe of long fine yellow hair on each scale, which seems to arise from a thickened border of the membrane. (Fig. 18).

The halteres or balancers are located on the metanotum and according to Lowne they are highly specialized organs of sense.

Though they appear to be rudimentary wings they are far from being vestigial organs. There are three parts, the scabellum (scm), or base, the scape or stalk (sce), and the head (hd) or the apical end (Fig. 11). The halteres are considered to be auditory organs and they carry a fluid in canals similar to the semi-circular canal of the higher animals, giving them the function of maintaining equilibrium.

The three pairs of legs are similar in structure and show slight sex differences. The main difference, which appears in all the legs, is that the bristles and spines of the male are stronger than those of the female. For the purposes of this paper, the legs will be spoken of as if they were drawn out at right angles to the body (Fig. 30). The surface which is then directed forward will be the anterior surface and opposite to it, the posterior surface. That surface which is above will be the dorsal surface and that opposite, the ventral surface.

In the prothoracic legs (Fig. 30A) the coxa (cx) in both sexes is longer than wide, of a somewhat irregular shape, and equipped with five stout spines on the dorsal or flexor surface. (Fig. 21A). The trochanter is small, somewhat triangular, and has no spines, and only one or two small hairs. (Fig. 24A and B). The femur (fm) of the male differs from that of the female in being strongly bowed. In both sexes this segment tapers slightly towards each end, and is armed with rows of strong spines on the posterior surface, two rows especially on the dorsal and ventral margins of the posterior surface (Fig. 28A). The anterior surface of the femur has a few irregular rows of small hairs. The tibia (ti) is as long as the femur, small at the base and slightly enlarged at the apex. (Fig. 31). In both sexes the tibia is armed with a pre-apical bristle and an apical spur. The tarsi (ts) are five-jointed (Fig. 36), the first being the longest and equipped with a distinct spine at its base and smaller ones below that on the ventral surface. (Fig. 36B). All the tarsal joints are pubescent and each of the first four has a weak apical spur (Fig. 36B). The fifth tarsal joint bears two stout, simple claws (clw), two pulvilli (pv), which are larger in the male than in the female (Fig. 34A and B), and a fine hair-like empodium (emp) (Figs. 35 and 36B and C). The tarsi of all three pairs of legs are similar, having no distinct differences. The pulvilli are membranous and covered with long, fine hairs which arise from conical protuberances on the

surface. (Fig. 36E). The tarsal joints are movable, being rather on the order of a ball and socket joint, the attachment between the first two allowing only limited movement (Fig. 36D), and one like that between the fourth and fifth allowing extreme freedom (Fig. 36F).

The mesothoracic legs (Fig. 30B) are the longest of the legs. The coxa (Fig. 20) is roughly diamond-shaped and flattened in a dorsal view, but as viewed anteriorly it consists of two halves. The dorsal half has four or five stout bristles on the dorsal margin of the anterior surface. The trochanter is roughly triangular with a coronet of hairs near the apex (Fig. 23A and B). The femur (Fig. 27) is long, tapering slightly at either end. There are eight strong bristles on the anterior surface, while the rest of the femur is covered with fine short hairs, except at the apex where there are two bristles. The tibia (Fig. 26) is slender, enlarging at its distal end. It is armed with two or three stout spines on its anterior surface, a pre-apical bristle and an apical spur.

The metathoracic legs (Fig. 30C) are of medium length in the male and as long as the mesothoracic legs in the female. The coxa (Fig. 19) is an irregular-shaped piece with one small, stout bristle on the dorsal surface and a row of small bristles on the distal margin. (Fig. 19B). The trochanter (Fig. 22) is somewhat irregular with a strong bristle on its ventral surface. The femur (Fig. 25) enlarges suddenly at the base and tapers slightly at its distal end. Starting at the base, at the dorsal angle, there is a row of stout bristles which curves irregularly on the anterior surface, ending near the apex. There is a row of five fairly stout bristles on the ventral surface. The tibia tapers slightly at the base and besides three strong bristles on the dorsal surface and two on the anterior and ventral surfaces, each, it is armed with a pre-apical bristle and an apical spur. All parts of the legs with the exception of the coxæ and trochanters are covered with rather coarse pubescence, or fine hairs arranged in more or less regular rows.

THE ABDOMEN.

When viewed dorsally, the abdomen appears to be composed of but four segments in the female and five in the male. There is, however, an imperfect suture which separates the first and second segments dorsally, and a plate which indicates the first segment as being distinct from the second ventrally.

The male abdomen (Figs. 37 and 38) differs from the female abdomen (Figs. 40 and 41) in shape, number of segments and form of the ventral plates. In general shape it is oval, the anterior end produced laterally, the posterior end blunt. It is about twice as long as broad and the segments, with the exception of the first and last, are of about equal widths. The female abdomen is about the same size as that of the male, but more pointed posteriorly, the second and fifth segments being the longest. The genital segments are barely visible in both sexes from above, and what appears to be the sixth segment in the male is the first genital segment. This is more apparent from the ventral view. Spiracles (sp) are visible on all five segments when viewed ventrally.

Ventrally the first segment is indicated by a short, wide ventral plate (vpl) connected to the dorsal sclerite by a membrane, the abdominal pleura. The second segment is produced into a ring at its anterior margin. The third and fourth ventral plates in both sexes are simple, rather long, and narrowed slightly posteriorly in the female, but almost square in the male. The fifth ventral plate (vp5) in the female resembles the third and fourth, but the fifth ventral plate of the male is complicated, being produced posteriorly into two long branches between which the forceps and genitalia lie when extended.

There are two genital segments in the male, the first a convex, somewhat ringlike segment, and the second (Fig. 37) is almost completely divided into two lateral halves with the anal opening (ao) between them. From the apical margin two branches project which are the forceps. The genital organs are found in the two genital segments but mostly in the second. (Fig. 32). At the posterior basal portion of the penis (pns) there is a hooklike process, the posterior clasper (cp) (Fig. 33). Opposite to this on the anterior side is located the anterior clasper (ca).

There is only one genital segment in the female, a small, ring-like segment, with an opening on its ventral surface, which serves as a genital and excretory opening. The genitalia are all internal.

For the most part the abdomen in both sexes is covered with hair, which is shorter and less dense along the median dorsal line. The first segment in the female has no distinct bristles, while the same segment in the male has a few bristles

along the posterior margin. All the rest of the segments have marginal bristles, those at the sides being longer and stronger than those near the median line. The ventral plates have only a few bristles at the margins and a sparse covering of hair towards the center. (Figs. 37 and 40). The first genital segment in the male has several long, strong bristles, while the second has a few along the posterior border. The forceps (fc) each have a distinct spur or tooth near the tip, and are covered with short bristles. The apical point of the second genital segment has two long, weak bristles (Fig. 37). The genital segment in the female has only a few short bristles on the ventral side (Fig. 40).

The chætotaxy of the abdomen is not constant, and the number of marginal bristles varies with the individual.

SUMMARY.

The head, with the exception of the face, the epicephalon and metacephalon, is apparently all one piece, divided into regions which are constant for both sexes. With the exception of the face, the anterior portion of the head is one piece, divided into distinct regions.

The chætotaxy of the head is constant for each sex and can be relied upon.

The thoracic sclerites in the two sexes are the same, and are constant.

The bristles of the mesonotum are constant with the exception of the weak acrostichal bristles which vary in number and arrangement.

The males are always equipped with three sternopleural bristles while the females have only two.

The hair covering of the pleural sclerites is the same in both, but not regular.

The third and fourth veins of the wings are either parallel or diverging at the tip, never converging, while the anterior cross vein is never perpendicular to the fourth vein, meeting the discal cell at its distal third.

The bristles of the legs are constant in location, but not in number, and an apical spur is present on all the tibia.

The abdomen has five segments, and one or two genital segments. The chætotaxy is not constant.

LIST OF ABBREVIATIONS.

ab.	Abdominal segment according to number.
acl.	Anal cell.
acr.	Acrostichal bristles.
acrv.	Anterior cross vein.
ads.	Anterior dorsocentral bristles.
ala.	Alula.
an.	Antennal joints according to number.
anf.	Antennal fovea.
ans.	Anepisternum.
ao.	Anal opening.
ar.	Arista joints according to number.
axcl.	Axilary cell.
axv.	Auxilliary vein.
bcl.	Basal cell. according to number.
bpl.	Basal plate.
bsu.	Basal suture.
bu.	Bucca.
c.	Cheek.
ca.	Anterior claspers.
cav.	Costa.
ccl.	Costal cell.
clw.	Claw.
cnd.	Condyles.
cp.	Posterior claspers.
cx.	Coxa.
dcl.	Discal cell.
e.	Compound eye.
emp.	Empodium.
ep.	Epistome.
epc.	Epicephalon.
epos.	Epioccipital sclerite.
ept.	Epaulet.
f.	Front.
fc.	Forceps.
fla.	Facialia.
fobr.	Fronto-orbital bristles.
fsu.	Frontal suture.
ft.	Frontal triangle.
g.	Genæ.
gn.	Genital segment according to number.
go.	Genital opening.
hcly.	Humeral callosity.
hd.	Head of halter.
hr.	Halter.
hm.	Humeral bristles.
ial.	Intra-alar bristles.
jscl.	Juxtascutellum.
l.	Lunule.
mcl.	Marginal cell.
mdtg.	Mediotergite.
merp.	Meropleurite.
mtc.	Metacephalon.
metm.	Meta-epimeron.
mtes.	Meta-episternum.
mtn.	Metanotum.
npl.	Notopleural bristles.
npls.	Notopleural suture.
o.	Ocelli.
obr.	Ocellar bristles.
ocf.	Occipital foramen.
om.	Oral margin.
ot.	Ocellar triangle.
pal.	Post-alar bristles.
pcl.	Posterior cell according to number.
pcly.	Postalar callosity.
pcrv.	Posterior cross-vein.
pd.	Prodorsum.
pds.	Posterior dorsocentral bristles.
phm.	Posthumeral bristles.
plsu.	Pleural suture.
pns.	Penis.
prc.	Paracephalon.
pres.	Proepisternum.
prf.	Parafrontal plates.
prnl.	Pronotal lobe.
prs.	Praescutum.
prsl.	Presutural bristles.
prsu.	Paracepalic suture.
psn.	Prosternum.
ptg.	Pleurotergite.
ptp.	Pteropleurite.
pv.	Pulvillus.
pvbr.	Post-vertical bristles.
pwp.	Pleural wing processes.
rm.	Remigium.
s.	Sella.
sal.	Supra-alar bristles.
sapl.	Sub-alar plate.
sc.	Scutum.
sccl.	Subcostal cell.
sce.	Scape of the halter.
scl.	Scutellum.
scla.	Scutellar apical bristles.
scm.	Scabellum of the halter.
sept.	Subepaulet.
smcl.	Submarginal cell.
so.	Sensory opening.
sp.	Spiracle.
spa.	Anterior thoracic spiracle.
spp.	Posterior thoracic spiracle.
sq.	Squama.
sqa.	Antisquama.
sqd.	Squamoid scale of the halter.
ssu.	Sternopleural suture.
stp.	Sternopleurite.
stpbr.	Sternopleural bristles.
tpm.	Tympanic membrane.
v.	Longitudinal vein according to number.
vbr.	Vibrissæ.
vcbr.	Vertical cephalic bristles.

EXPLANATION OF PLATES.

Plate XVII.

Fig. 1. Anterior view of female head.
Fig. 2. Anterior view of male head.
Fig. 3. Lateral view of female head, right side.
Fig. 4. Lateral view of male head, right side.
Fig. 5. Face, a facial sclerite which bears the antennæ.
Fig. 6. Antenna, showing joints and sensoria.
Fig. 7. Posterior view of male head.
Fig. 8. Antennal arista.

Plate XVIII.

Fig. 9. Dorsal view of thorax of male.
Fig. 10. Anterior view of prothorax of male.
Fig. 11. Halter.
Fig. 12. Lateral view of male thorax, right side.

Plate XIX.

Fig. 13. Wing of male, right wing.
Fig. 14. Epaulet, sub-epaulet, and base of the costa, of the right wing.
Fig. 15. Remigium, of right wing of a male, showing chordonotal organs.
Fig. 16. Left side of male to show squamæ.
Fig. 17. Posterior spiracle of male.
Fig. 18. Edge of squama.

Plate XX.

(Legs taken from the right side of male.)

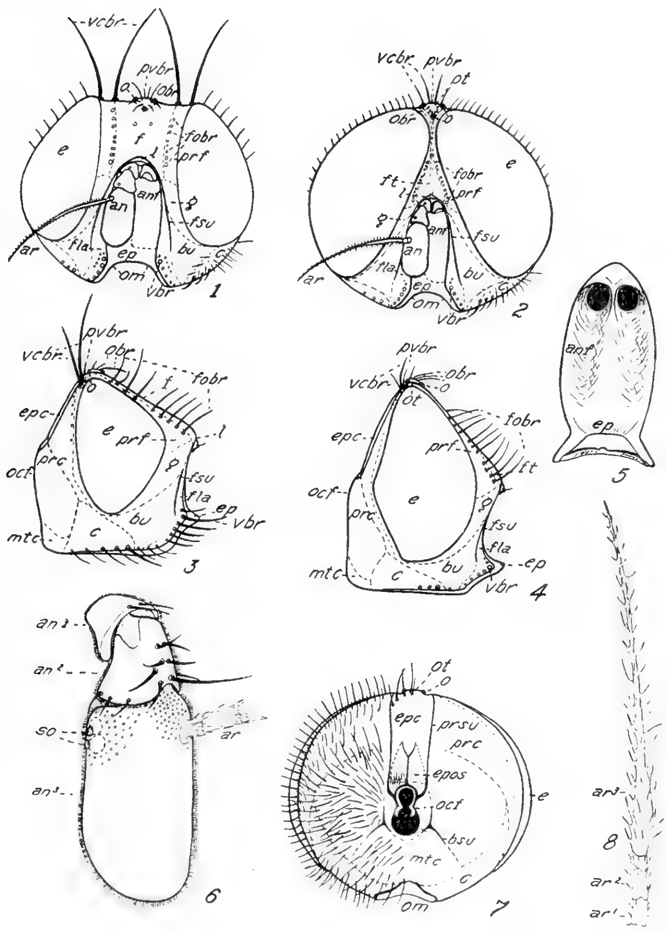
Fig. 19. Metathoracic coxæ of male. A, Dorsal view. B, Anterior view.
Fig. 20. Mesothoracic coxæ of male. Dorsal view.
Fig. 21. Prothoracic coxæ of male. A, Dorsal view. B, Anterior view.
Fig. 22. Anterior view metathoracic trochanter.
Fig. 23. Mesothoracic trochanter. A, Anterior view. B, Dorsal.
Fig. 24. Prothoracic trochanter. A, Posterior view. B, Ventral.
Fig. 25. Metathoracic femur, dorsal view.
Fig. 26. Mesothoracic tibia, anterior view.
Fig. 27. Mesothoracic femur, dorsal view.
Fig. 28. Prothoracic femur. A, Posterior view. B, Dorsal view.
Fig. 29. Mesothoracic tibia, dorsal.
Fig. 30. Anterior view of legs in position as described. A, Prothoracic, B, Mesothoracic. C, Metathoracic.
Fig. 31. Prothoracic tibia, posterior view.

Plate XXI.

Fig. 32. Second genital segment and genitalia of the male.
Fig. 33. Genitalia with genital segment and forceps removed.
Fig. 34. Pulvilli. A, Male. B, Female.
Fig. 35. Apex of last tarsal joint of male, posterior view.
Fig. 36. Tarsus. A, Dorsal view of first joint, (outline). B, Posterior view of all tarsal joints. C, Dorsal view of last two tarsal joints. D, Union and articulation between first two tarsal joints. E, Edge of pulvillus showing roughened surface. F, Union and articulation of last two tarsal joints.

Plate XXII.

Fig. 37. Ventral view of male abdomen.
Fig. 38. Dorsal view of male abdomen.
Fig. 39. Section of abdominal wall to show flexibility of segments.
Fig. 40. Ventral view of female abdomen.
Fig. 41. Dorsal view of female abdomen.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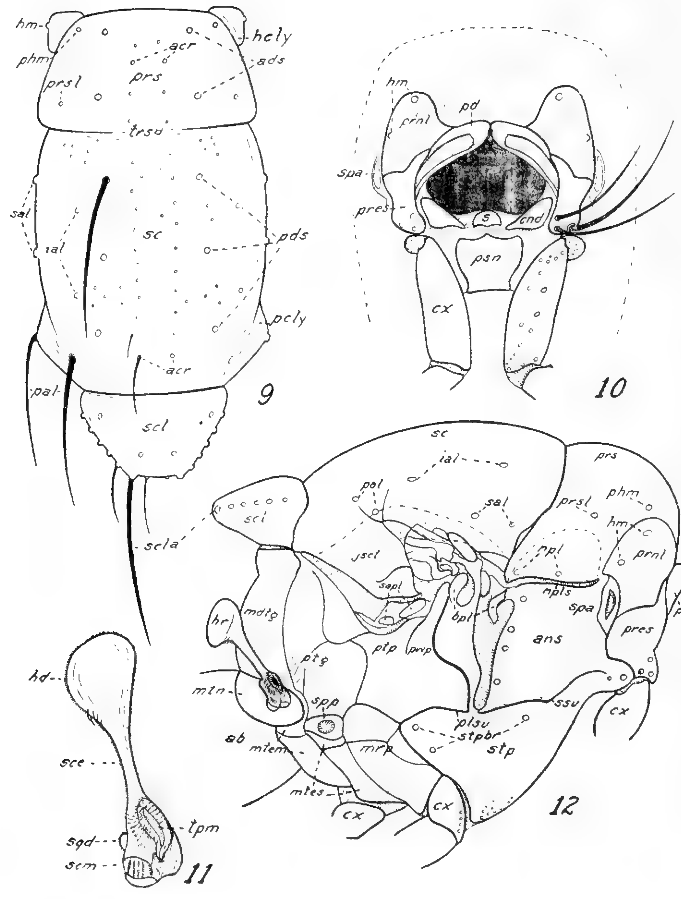
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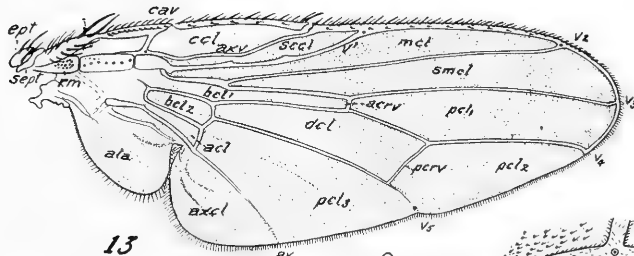

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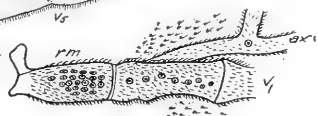

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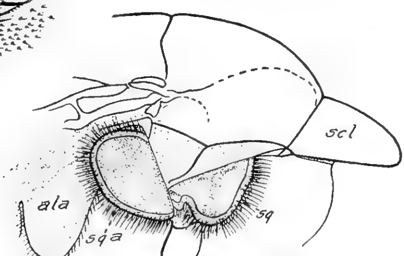

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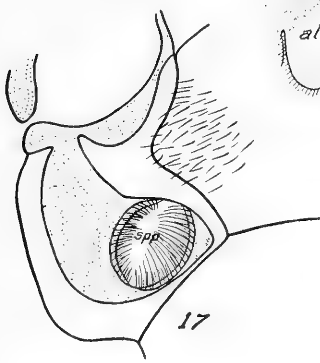

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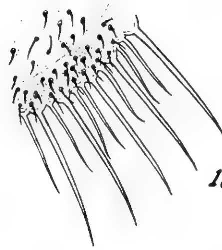

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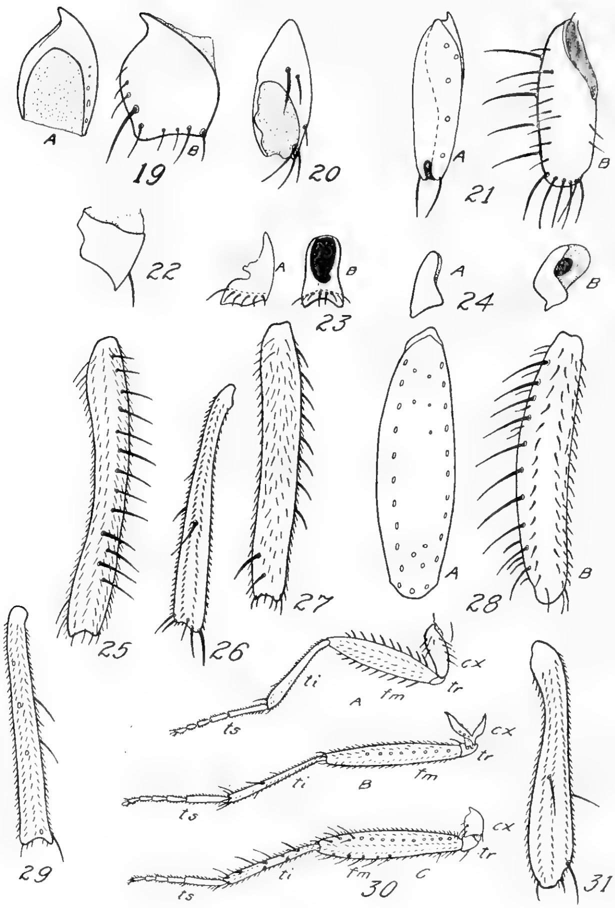
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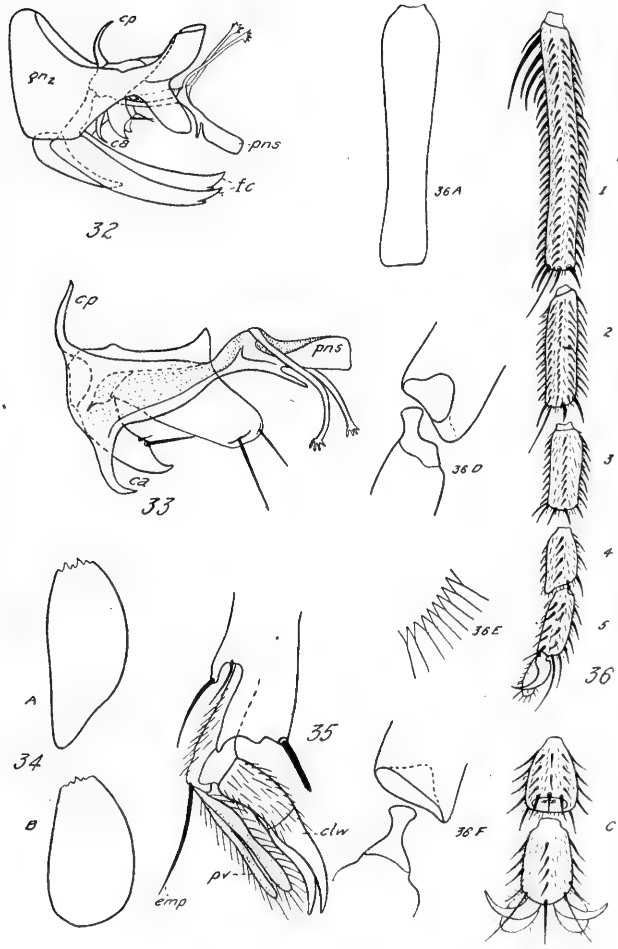
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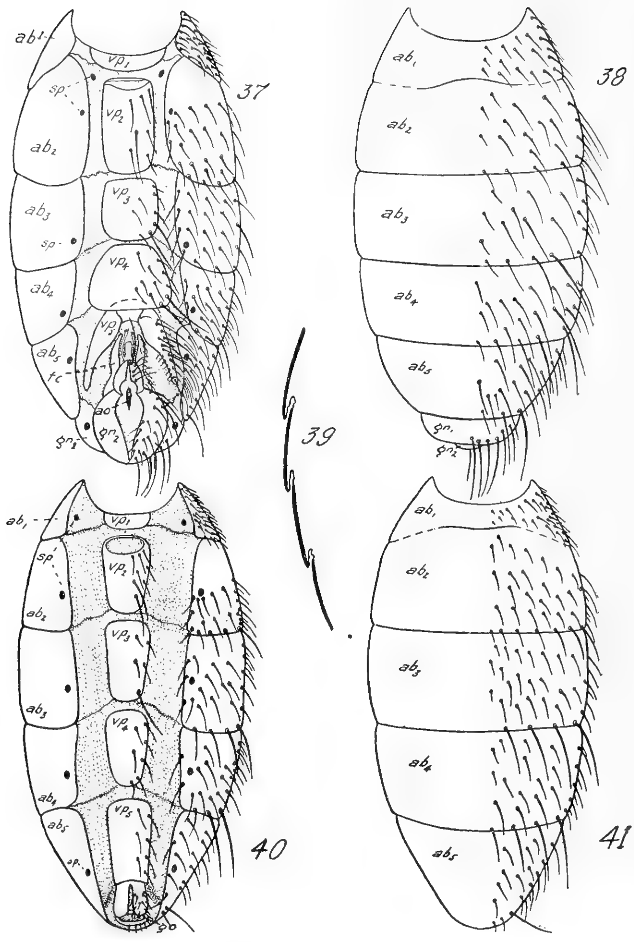

H. L. Seamans

THE DIGESTIVE SYSTEM OF THE PERIODICAL CICADA, TIBICEN SEPTENDECIM LINN.

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I. Morphology of the System in the Adult Insect.

I. Introduction.

Numerous authors have reported the impossibility of following the digestive system of the periodical cicada throughout its entire length. Of those who state that it is complete and well organized, none attempts any detailed description. My attention was called to the matter in 1916 by Dr. C. W. Hargitt who had himself been interested in the question of digestive activity in this insect for some years. Dr. Hargitt's observation dealt particularly with the feeding habits of the cicada. He had also directed a graduate student, R. L. Henderson, in an attempt to work out the morphological details of the enteron. Unfortunately before this work was completed the death of Mr. Henderson intervened.

In the present work I have constantly consulted with Dr. Hargitt, but the entire responsibility for the morphological details herein presented lies with me. A further publication, in which Dr. Hargitt has the major interest, dealing with the physiological aspects of the problem, will appear shortly.

II. Literature.

There has been much lack of agreement in the literature as to whether the cicadas do or do not feed and this question has led in turn to the inquiry as to whether the digestive tube is atrophied in the supposed cases of non-feeding. Marlatt (1898) in his summary of the habits of the insect, says that during its aerial existence "it seldom, if ever, takes food." In

another place he says that feeding is limited to the female, the digestive system of the male being rudimentary.

Quaintance (1902) made a series of careful observations upon the brood which emerged in Maryland during the early summer of 1902. He was able to find numerous insects, both male and female, apparently feeding upon the branches of young fruit trees. He snipped off an insect's proboscis while the latter was embedded in the bark of a twig and shows a photograph of a section of this bark pierced by the setæ. He states that he found that the alimentary tract was not rudimentary in either sex, although he attempts no description nor gives any figures to prove his statement.

Hargitt (1903) suggested that there seems to be a complete atrophy of the hind gut at the time of emergence while the mid-gut undergoes an increase in size until the abdomen is almost entirely hollow. He suggests that this condition represents an adaptation enabling the insect to make use of the stored fat, using this food to the exclusion of plant juices.

Marlatt (1907) in a revision of his earlier bulletin corrects his former statements regarding the feeding habits of the cicada. He is convinced of the possibility of feeding by the observation of Quaintance, but still questions whether the cicada necessarily takes food.

In an unpublished paper by R. L. Henderson, under the direction of Dr. Hargitt, to which we have had access, numerous observations were recorded which have proven valuable in this study. Although Henderson did not work out the digestive system completely, his account shows that he had identified and traced the course of certain parts of the canal.

Dufour ('33) describes and figures the digestive system of *Cicada orni*. In general his findings are very similar to those here presented for *Tibicen septendecim*, except that he did not recognize the complication of crop and "internal gland." According to Dufour the esophagus dilates posteriorly to make the crop. The crop continues into the "poche du ventricule chylifique." Then follows a smaller much-coiled tube which finally runs forward, apparently emptying into the anterior portion of the "ventricule chylifique." The crop gives off a lateral diverticulum which continues posteriorly as a narrow, much-coiled tube and finally empties into a short rectal division which ends at the anal opening.

From the above it is evident that there is no agreement as to the necessity of feeding in the adult insect nor has the morphology of the digestive system been worked out sufficiently, in *Tibicen septendecim* or any closely related forms, to warrant inferences as to functional activity based upon structural conditions.

III. Material and Methods.

The observations herein recorded are based upon the periodical cicada, *Tibicen septendecim* Linn. Numerous specimens of the so-called dwarf cicada have been collected, but they were not used in this work. Material was collected during June, 1916, by the author in the vicinity of Syracuse. Additional insects were gathered near Moores Hill, Indiana, by Dr. A. J. Bigney.

The material was fixed in the following fluids: Bouin, 10% formol, sublimate acetic, Gilson, potassium dichromate, and Zenker. In order to insure rapid penetration of the fluids, the integument was slit with a razor on the ventral side, or the head was cut off allowing the fluids to penetrate rapidly from the anterior end.

Dissections of freshly killed and also of preserved insects were made under the binocular microscope. The dissection method was not sufficient to reveal all of the relationships of the digestive organs so that serial sections of entire insects, as well as of parts of the digestive tube with adhering tissue, were made.

In making serial sections of entire insects it was necessary to soften the chitinous integument by means of Labarque's solution. After this process the insects were embedded by the double method of Apathy and sections were cut ten microns thick. Such sections were valuable only for determination of general topographical relationships.

The various digestive organs were dissected out and serial paraffine sections 5 microns thick were made in the usual manner. They were stained with hematoxylin and eosin. By means of these sections various relationships were made apparent which could not be cleared up by gross dissections.

IV. The Digestive Tube in the Adult Male Insect.

The male has been chosen as the subject for more detailed description because of the fact that in this sex particularly more doubt has been expressed as to the completeness of the enteric canal.

In the cicada it is difficult to recognize the boundaries of the fore, mid and hind guts. Not only do these parts fail to conform in their gross anatomy to the relatively simple divisions as found, for example, among the Orthoptera, but their histological structure also fails in most cases to correspond with that of the more familiar forms. The puzzling relationship of parts and the changes taking place in some of these parts during the life cycle may be due to any or all of several factors, viz., the nature of the liquid food; the influence of food stored in the body in the form of fat; or to the peculiar life history of the insect. However, since most of the sap-sucking Hemiptera in which the digestive apparatus has been described have some similar peculiarities, no clue is obtainable from them as to the significance of these conditions. That part of the following description relating to the sequence of parts in the tube and to their general relationships can best be understood by reference to Fig. 3. This is entirely schematic and attempts to represent none of the finer details of structure.

The extreme anterior portion of the digestive canal is not greatly different from that described for numerous other forms. The long proboscis, containing a pair each of functional stylet-like mandibles and maxillæ, leads dorsally through the pharynx into the narrow esophagus. The latter, when it reaches a point midway between the dorsal and ventral surfaces of the animal, turns at right angles and proceeds toward the posterior end. The point where the esophagus changes direction is just posterior to the boundary between the head and prothorax.

The esophagus does not vary much in diameter throughout its entire extent, (Figs. 2 and 3). It may, with little difficulty, be followed in a properly dissected specimen, with the unaided eye, and it is easily traced with a lens of low magnification. At the line of division between the mesothorax and the metathorax the esophagus empties into the crop.

The crop is divided into two parts of unequal size. The anterior part (Figs. 1, 2 and 3, ac) is the smaller and is usually

confined to the metathorax. The posterior portion (Figs. 1, 2 and 3, pc) has its anterior boundary at the beginning of the first abdominal segment. Its extent in the posterior direction is variable and this variation will be discussed later but in extreme cases its posterior boundary is found as far back as the sixth abdominal segment.

The dorsal wall of the anterior crop is concealed by a winding mass of tubes which will be described later. For want of a better name this mass will be called the "internal gland," following the terminology of Lubbock ('59). Although Lubbock probably intended his designation to include more than it does in the present case, it seems expedient to continue the use of the term in connection with that part of the complex made by the ascending intestine and malpighian vessels just above the anterior crop. In shape, this complex of crop and internal gland usually appears as an elongated spheroid, but it may be bent upwards so as to look in side view like an inverted U. The diameter of the entire structure is roughly five times that of the esophagus. Posteriorly it narrows and apparently connects with the large posterior crop.

The descending intestine arises from the left side of the internal gland near its anterior margin. In a gross dissection this tube sometimes appears to be a continuation of the esophagus but sections of this region show it to be otherwise, as will be explained later. It is only about half the diameter of the esophagus and is characterized by a gray color which is uniform throughout its whole extent. It follows the ventral margin of the anterior crop but leads in a general posterior direction. The windings of this tube are confined in most cases to the dorsal half of the insect. At the boundary between the sixth and seventh abdominal segments it winds upon itself in such a way as to make a knot (Figs. 1, 2 and 3, kk). From this knot or coil the tube emerges and joins the rectum which latter narrows as it passes posteriorly until it ends in the anal opening.

The posterior end of the internal gland receives another tube (Figs. 1, 2 and 3, at) which is distinguishable from the one previously described both as to its color and also with regard to the course it takes. Its color is noticeably yellow, a condition as will be shown later, traceable to the precence of cytoplasmic inclusions in the epithelium of its walls. This yellow tube, the ascending intestine, also runs in a sinuous fashion over the sur-

face of the posterior crop but is chiefly confined to its ventral surface. Following the intestine backward it may be traced to the posterior boundary of the sixth abdominal segment where it takes a dorsal course toward the rectum. As in the case of the descending intestine, a knot or coil is formed (Figs. 1, 2 and 3, k) but when the tube emerges from the coil, it turns anteriorly and connects with the posterior crop at the extremity of the latter (Figs. 1 and 2, x).

The posterior crop is one of the most puzzling divisions of the tube at first sight. It is enormously developed, especially in the adult male during later life, and its gradual enlargement from the period of emergence to late life is one of the anomalies demanding adequate explanation. Because of the thinness of parts of its walls its true nature might be unsuspected if one depended upon gross dissections alone. In the adult male it extends from the metathorax to the end of the sixth abdominal segment (Figs. 1, 2 and 3, pc). An anterior cæcal prolongation extends forward beneath the crop as indicated in Fig. 3. Its main portion gradually enlarges posteriorly except for indentations at the boundaries of one or two segments until, beginning in the region of the second abdominal segment, its walls closely approximate the chitinous integument on all sides. The small intestinal tubes connecting fore and aft with the internal gland run their courses upon its outer surface as indicated above.

The rectum is confined usually to the last two abdominal segments (Figs. 1, 2, 3, r). It is an elongated sac with numerous longitudinal folds and lies close to the dorsal integument. It is easy to understand how some writers may have gotten the impression that the digestive tube of the male insect did not have any complete posterior portion, for in all cases where a dissection is attempted from the dorsal side the rectum is destroyed. It is practically impossible to remove any part of the dorsal integument in this region without injuring the underlying rectal sac. It can be exposed, however, by carefully dissecting from the ventral side, through the mass of coiled reproductive ducts and fat.

The foregoing description is based entirely upon observations in the adult male insect. While the female organs are arranged on the same general plan, there are slight variations and these will be mentioned in another place.

From what has been said it should be apparent that the adult male cicada possesses a digestive tube which is most peculiar both with respect to elements which compose it and to the manner of their arrangement. It is possible to demonstrate by dissections alone, that this insect has a complete and continuous digestive tube yet this fact has been denied by many, and even when admitted, the arrangement and connections of the organs have been imperfectly understood. The relationships of the various parts described must depend upon the study of sections, for it will shortly appear that certain apparent connections between elements as indicated in whole preparations are indeed apparent and not real.

RELATIONSHIPS OF THE DIGESTIVE ORGANS.

As suggested above, the connection between the various parts of the digestive system are not very clear in gross dissections. The actual union of some of the different divisions of the system can be clearly demonstrated only in sections.

With the view of determining the true nature and relationships of parts in the anterior part of the digestive tube, the crop with the internal gland was dissected out of numerous adult insects. Transverse, sagittal and frontal sections were cut, and by means of these the independence of crop and internal gland was established. A median sagittal section of the anterior part of the tube shows that the esophagus is separated from the crop by a valve and that the anterior crop then continues in a posterior direction. As it proceeds, however, its walls become much modified, the floor being greatly thickened, while the roof is relatively thin and much folded. The folds in the roof are very pronounced and run in a general antero-posterior direction. This condition results in the formation of deep external fissures on the dorsal surface of the anterior crop, the ascending intestine and malpighian vessels each being enveloped by the walls between two adjacent folds. These relationships may be understood by reference to Fig. 9, which is a transverse section through the anterior crop region. The same structures are also represented diagramatically in Fig. 6.

This modified anterior crop upon reaching the posterior portion joins directly with the latter. The aperture leading into the posterior crop is small and irregular by virtue of the convoluted walls of the connecting portions. While the dorsal

wall of the anterior crop is thin and has its epithelium poorly developed, this does not imply that there is any connection with the tubes which coil above this region. The anterior crop receives no tube, other than the esophagus, nor does it give off outgrowths in any part.

It was stated previously that the descending intestine, arising from the left anterior part of the "internal gland," looks, in a dissection, as if it might be a posterior continuation of the esophagus. Sections do not confirm this possibility. On the contrary, a frontal section (Fig. 7) shows the descending intestine to be continuous with the ascending intestine. The latter enters the internal gland posteriorly and runs forward to its anterior margin. A comparison of sections in three different planes proves, then, that the enlargement in the metathorax is composed of two distinct parts—a dorsal, tubular, closely-wound mass made by the ascending intestine and malpighian vessels, and a ventral distensible portion continuous with the esophagus.

The posterior crop neither receives nor gives off any outgrowths until its extreme posterior end is reached. Sections show (Fig. 14) that it empties directly into the narrow ascending intestine which then proceeds in a general anterior direction to join in the formation of the internal gland, as previously described. A muscular ring or valve is found at the junction of the last mentioned parts.

There are four malpighian vessels. They are easily found in any section between the crop and rectum. They are not easily distinguished in dissections since they are almost the same in color as the fat which surrounds them. Their diameter is about half that of the intestine. The blind ends of the tubules lie in the extreme posterior end of the body. They run forward in irregular fashion, mostly dorsally, until they approach the region of the anterior crop. Here they describe a short loop just above the internal gland and then disappear into it at its posterior margin.

From the foregoing descriptions it is clear that if plant juices are taken in as food, they are conveyed to the anterior crop directly through the esophagus. They then pass to the posterior crop which, in all probability, functions as a storage sac as well as contributing to the digestive process. From the posterior crop the liquid food passes into the ascending

intestine through which it goes anteriorly until it reaches the internal gland. After traversing the latter it again starts in a posterior direction through the descending intestine and finally enters the rectum, the last organ of the system. There seems to be no possibility that the food material takes any other course than that outlined above. There are no connections between the parts described which would permit any other course, and the presence of valves shows that the food stream could follow only the direction outlined.

HISTOLOGICAL STRUCTURE OF THE DIGESTIVE ORGANS.

The Esophagus.

The epithelium of the esophagus has no prominent cell boundaries. Here and there can be seen cells whose free margins are separated by walls, but for the most part the epithelial lining appears as a syncytium. The nuclei are prominent, being large and containing numerous chromatic granules rather evenly scattered. The nuclei do not all lie near the proximal ends of the cells, but appear near the distal border as well.

The cytoplasmic portion shows no differentiation between basal and free ends, but is uniformly made up of fine granules or minute fibrillæ which seem to compose the more solid portion of the cytoplasmic mass. Here and there are found vacuolar spaces within the cytoplasm, but in no place does one find cytoplasmic inclusions which could be considered as evidence of secretion or absorption. The latter statement is based upon observations upon sections from numerous insects of different ages in which a wide variation as to activity in feeding was possible. The free margin of the epithelium is bounded by a definite wall, but there does not appear to be any cuticula or striated border. The epithelium lining the esophagus would seem, from these observations, to have a purely passive function, conducting the food material posteriorly, but not contributing otherwise to the digestive or absorptive processes.

The cells of the esophageal epithelium have a well developed basement membrane. Connective tissue elements thicken this in places (in the middle of the folds, for example) in such a way that the folds seem to have a dense core of darkly staining material in which the details of structure do not show them-

selves plainly. This layer of connective tissue elements may be traced entirely around a transverse section.

Adjoining the basement membrane are found two or three layers of muscles—an inner longitudinal and an outer circular layer. The longitudinal layer is not well developed, but consists of scattered bundles of fibres which fit into irregularities at the bases of the epithelial folds. Each muscle is composed of from one to a dozen fibres. The poor development of this layer would suggest that it has little if any functional importance. The circular layer is better developed. It consists of several strata of striated muscle fibres which interweave, making a network (the individual fibres do not branch), which surrounds the tube. Muscle nuclei are not prominent in the layers, but the fibres are easily seen and studied.

In many parts of transverse sections other groups of longitudinal muscle fibres are found outside the circular layer above described. These are numerous and well developed in contrast to the longitudinal layer lying at the base of the epithelium. Inasmuch as the esophagus lies between the large thoracic muscles which attach to the appendages, it is likely that the last described elements are members of this thoracic muscle mass.

The succession of layers above described corresponds rather closely to that in the esophagus of other insects. There is, therefore, nothing remarkable about this organ in a structural sense.

The lumen of the esophagus is continuous with that of the anterior crop through a narrow passageway running between well-developed epithelial folds. These folds have at their bases circular muscles and much connective tissue. A longitudinal section of this region shows that this arrangement is a real valve with a sphincter. It must, therefore, function in preventing the flow of juices back into the esophagus once they have arrived in the anterior crop cavity. On the esophagus side of the valve the epithelium is not folded but gives a funnel shape to the lumen as it runs posteriorly. On the crop side, however, the epithelial lining is thrown into numerous folds (Fig. 10), especially at the point nearest the actual opening in the valvular structure. Liquid going in the wrong direction would thus be hindered in its progress by the folds and a con-

traction of the sphincter would so close the lumen as to prevent effectively passage of any liquid.

The Anterior Crop.

The esophagus empties into the anterior crop through the narrow opening described above. The walls of this division are not uniformly differentiated (Fig. 9). The floor of the organ is so constructed as to permit little expansion. The roof is much folded, the folds apparently allowing some distension as a result of the pressure of the contained liquid food. These differences of structure are easily observed in either longitudinal or transverse sections.

The epithelium covering the floor of the anterior crop is made up of columnar cells varying somewhat in length. Anteriorly its surface is thrown into a series of gentle folds (Fig. 8). The folds increase in height until in the extreme posterior end they much resemble the gastric crypts of some of the vertebrates. The cell boundaries, easily seen in the distal portions of the cells, become less sharply marked as the base of each cell is approached. The cytoplasm of the cells is uniformly granular or homogeneous. No vacuoles or secretion products were observed. The nuclei are large and chromatic and they may be found in almost any position between the base and free ends of the cells. No cuticula or striated border was observed, the free ends of the cells having membranes similar to those covering the basal portions.

The roof of this division has an epithelium much different in character from that above described. The cells are more cubical than columnar. The dorsal folds are very deep (Fig. 9) while secondary folds branch off from the one or two large primary ones in such a fashion that in transverse section the pattern formed resembles the branches of a tree. There is a pronounced cuticula developed upon the surface of the dorsal epithelium.

Cross sections through any part of the anterior crop region show the ascending intestine and malpighian vessels to be closely apposed to the dorsal wall of this organ. These tubes lie in the depressions between the folds previously described but do not actually penetrate the folds at any point.

The entire mass formed by anterior crop and entwined tubes is covered with a peritoneal membrane together with some muscle fibres. The resulting saccular appearance and the

apparent unity of the structure as viewed externally, together with its likeness to glandular tissue as seen in section accounts for the name "internal gland" applied by other authors. The term is retained here only as a convenient designation and for want of proper name which will suggest its real anatomical or physiological nature.

The passageway between anterior and posterior crop is small and irregular in outline. Both divisions of the crop are much folded in a longitudinal direction at their point of junction. This makes a narrow, tortuous connection, at least when the two parts are not distended with food. The circular muscles in this region are not well developed so that there does not appear to be any valvular apparatus for the separation of the two cavities.

The anterior end of the second division of the crop has its walls much folded. These folds are so close to each other that the lumen is a mere irregular slit. The epithelium in this region is not greatly dissimilar to that found in the floor of the anterior crop. The muscles in the walls of the posterior crop are arranged in an inner circular layer which is thin and evenly disposed, and an outer longitudinal layer whose fibres lie in scattered groups close to the circular layer.

In the anterior portion of the posterior crop the epithelial cells are packed with oval brownish inclusions similar to those found in the ascending intestine, described later.

In the middle portion of the posterior crop the epithelium thins out to such an extent that it forms the thinnest of lining membranes (Figs. 12 and 13). The cells lose their columnar character and become cuboid or even squamous. Cell boundaries are indistinct or entirely lacking. The free border of these cells has a striated zone beneath which is a narrow dense layer of granular cytoplasm followed by colorless alveolar substance which is probably made up of small vacuoles filled with fluid. The proximal portions of the cells are filled with a finely granular protoplasm. The muscle layers are not well developed although they may be demonstrated in certain places.

In the posterior end of the posterior crop the epithelium becomes somewhat thicker, especially so at the point where the ascending intestine connects with it. Here again the cells show the yellow inclusions which look somewhat like oil droplets. These are similar in appearance to those found in the most anterior portion.

The opening from posterior crop into the ascending intestine is surrounded by a sort of transitional epithelium. Here the cells are tall and closely packed. They are thrown into slight folds (Fig. 14) but not to the extent found in some other portions of the digestive epithelium. There is a well-developed layer of circular muscles at the place where the tube arises, presumably a sphincter or valve, guarding the opening into the ascending intestine.

The Ascending Intestine.

The ascending intestine, in histological structure, shows great difference from the parts previously described. The lining of this tube is composed of a single layer of irregular epithelial cells which, when fully developed, are very large (Figs. 15 and 16) and have a prominent, centrally-located nucleus. Of all the digestive epithelia thus far considered, that of the ascending intestine seems to be most active. The cytoplasm at the base of each cell is granular, but as the free end of the cell is approached large globules are developed (Fig. 16). When the globules are not present, vacuoles of varying sizes are found in the protoplasm near the distal ends of the cells (Fig. 15).

The nuclei of the large fully-developed epithelial cells become vacuolated just previous to secretion. At the bases of the larger cells are found numerous small replacement nuclei which suggest the method by which new cells are formed to take the place of those cast off. In Fig. 17 the lighter colored cells are apparently in process of developing to replace those destroyed by secretory activity, while the darker ones are about to secrete. The free margin of the cells is bounded by a well-developed striated border. This is so prominent that at certain times it gives the cells the appearance of being clothed with short cilia.

The epithelial cells lining the entire tube from its place of origin to the point where it goes into the internal gland show signs of functional activity of the sort above mentioned. Figs. 15, 16 and 17 represent different phases of the secretory process.

At the base of the epithelial layer is a thin stratum of circular muscle fibres. In some places this is hard to distinguish from the basement membrane of the epithelial cells.

Just outside of the circular muscle layer scattered bundles of long muscle fibres are found. This incomplete long muscle layer is not different in character from that described for the anterior crop.

The Malpighian Tubules.

The walls of the Malpighian tubules are made up of a single layer of cuboid cells. The nuclei of these cells are large and sometimes irregular. The cytoplasm is granular or alveolar depending upon the phase of the secretion process. A well developed intima is present in the cells. In certain places a tubule may be made up of enormous cells placed end to end, in which case there is a single large intracellular duct into which drain numerous smaller ducts which ramify in the cytoplasm in a lateral direction.

At the point where the tubules enter the "internal gland" there is an abrupt change in the character of their walls. They become thin, the nuclei decrease in size and are less chromatic. They retain this membranous character until they finally empty into the intestine near the anterior margin of the "internal gland," at the junction of the ascending and descending intestine.

The "Internal Gland."

As previously explained, the name "internal gland" was used by Lubbock in 1859 to denote the closely wound knot formed by a part of the digestive tube in the thoracic region of certain Hemiptera. The term is here used to designate the complex formed by the ascending intestine and malpighian vessels dorsal to the anterior crop.

The ascending intestine, after running almost the entire length of the abdominal cavity, in the manner previously described, begins a series of coils just above and closely apposed to the dorsal wall of the anterior crop (Fig. 3). Immediately before entering this coil the diameter of the tube becomes somewhat enlarged and there appears to be much secretory activity on the part of the cells of its epithelial lining for they are much vacuolated both as to cytoplasm and nuclei and the free ends of the cells become cast off into the lumen to a greater extent than in the cells nearer the end where the tube originates.

The tube then becomes closely wound upon itself and as it proceeds forward lies close to the wall of the anterior crop. Signs of functional activity are not as pronounced as the tube is followed forward. The cells contain few or no secretion bodies or vacuoles. Cell particles also cease to be cast into the lumen of the tube.

The malpighian tubules accompany the ascending intestine forward contributing a large percentage of the mass of the "internal gland." Their walls become extremely thin while the lumen of each vessel increases greatly in size. These conditions are represented in Figs. 7 and 9 mt.

The Descending Intestine.

While the ascending intestine emerges from the internal gland its epithelium becomes markedly changed. The cells are low and flat and contain no cytoplasmic inclusions. As the tube leads posteriorly the epithelial lining takes a transitional form. This point marks the entrance of the malpighian vessels and the junction of the two intestinal divisions.

The descending intestine is lined with a single layer of large epithelial cells. Anteriorly these cells are vacuolated (Fig. 18), but in the middle and posterior parts the cytoplasm is uniformly granular (Fig. 19). The lumen of the tube is irregular in outline by reason of the triangular shape of the limiting cells. These cells are bordered by a zone of cytoplasm much denser than that found centrally. This dense peripheral zone is distinguishable in the basal parts of the cells next to the underlying muscles as well as at their free borders. This condition reminds one strongly of the ectoplasmic and endoplasmic zones in protozoa.

The nuclei of these cells are large and centrally placed and contain many coarse chromatic granules. Nucleoli do not appear nor are the nuclei vacuolated as was the case in the ascending intestine. The cytoplasm surrounding the nucleus is finely granular or fibrillar, except in the region immediately following the emergence from the internal gland (Fig. 18). Here both cytoplasm and nucleus may show vacuoles. It is to be noted that here also the vacuolation is not accompanied by the modification of the outer zone of protoplasm as previously described.

A comparison of sections of the ascending and descending intestine shows that their color is due to the histological structure of the cytoplasm in each case, the yellow color of the former being caused by the numerous inclusions. The complete absence of these in the descending intestine results in a color difference which enables one to recognize this tube with the naked eye.

The Rectum.

The rectum is relatively short and its diameter is much greater than that of any part discussed thus far except the posterior crop. Its walls are also much thicker than those of any other part of the digestive tube. The epithelial lining is similar to the esophageal epithelium in that the columnar cells are narrow, closely packed, thrown into numerous small folds, and the cell boundaries are indistinct. The muscle layers do not have their fibres running in strict longitudinal and transverse directions, but there are many strands of muscle material running in criss-cross fashion so that a sort of woven mat of tissues makes up the muscular part of the rectal walls. In places, however, distinct layers may be seen, an inner thin longitudinal layer and an outer thick circular layer. The muscle is of the striated variety in both layers and is gathered into typical bundles. The great thickening of the circular layer is not surprising in view of the functional activity of this layer in emptying the rectal cavity.

V. Relative Conditions in Male and Female.

The different divisions of the digestive tube in the female adult do not differ greatly from those described in detail for the male. The gross and microscopic arrangement of parts is the same in general plan. Esophagus and anterior crop are practically identical in structure in the two sexes. The posterior crop is much smaller in diameter in the female, its walls being crowded together by the surrounding fat and reproductive organs, but the walls themselves are similar in structure to those of the male. Ascending and descending intestine and rectum show no structural differences in the two sexes. There is, then, no great difference in the general plan and arrangement of the digestive organs of the male and female.

A gradual increase in the size of the posterior crop during the adult life of the cicada is noticeable. This increase in size is accompanied by a corresponding gradual decrease in the volume of the fat body. This results in the cavernous abdomen of the adult in its final period of existence, a condition especially striking in the male, but also observable in the female during its later history. Since the space necessary for the accommodation of the eggs is much larger than that required to store the sperms, this may account in part for the smaller average size to which the posterior crop attains in the female.

VI. Discussion.

The relationship of parts in the digestive system of Cicada orni, as described by Dufour ('33), is unintelligible when the gross anatomy of the organs are alone considered. On the basis of what we have found in sections of the same system in *Tibicen septendecim*, however, it seems easy to homologize the structures described by Dufour with the corresponding ones in the present subject and to suggest further that the two much-coiled portions of the intestine figured for *C. orni* are connected by a labyrinth similar to the one described here as the "internal gland." Dufour did not study sections of his material and ordinary dissection methods would not reveal the relationships which are made plain by sections. If, in *C. orni*, there is any difference between the digestive systems of male and female, Dufour's figure is undoubtedly that of a female specimen. At any rate, the digestive apparatus is nearly identical with that of a female *Tibicen septendecim*. The one slight variation, namely, the point of connection between the ascending intestine and "internal gland," is easily explainable since the anterior portion of the posterior crop is usually much folded in these forms and the ascending intestine might be so placed between folds, and perhaps in addition have its wall actually grown fast to those of the ascending intestine, so as to appear to empty into the "ventricule chylifique" (posterior crop). Examination of Dufour's figure of the digestive system of *Cicada orni* after studying sections of the same in *Tibicen septendecim* does not leave much doubt as to the similarity of the digestive apparatus in the two species.

VII. Summary and Conclusions.

1. There is a well-differentiated and continuous digestive tube in both male and female adult *Tibicen septendecim.*
2. The esophagus, which empties into the crop, shows no peculiarities of structure.
3. The crop is divided into two unequal parts (the anterior and posterior crops) by a constriction at the place where thorax and abdomen join.
4. The crop is partially obscured by a mass made up of ascending intestine and malpighian vessels. This mass has been called the "internal gland" (Lubbock '59).
5. The posterior crop is greatly enlarged, especially in the adult male, and its epithelium is extremely thin except at the extreme anterior and posterior ends.
6. The posterior crop empties into the ascending intestine which is yellow in color and runs forward until immediately dorsal to the anterior crop it winds about with the malpighian vessels to make the "internal gland."
7. The ascending intestine emerges from the internal gland and empties into the descending intestine.
8. The malpighian vessels are four in number and they empty into the digestive tube at the junction of ascending and descending intestines.
9. The descending intestine runs dorsally in a general posterior direction until it joins the rectum. The former is gray in color.
10. There is no degeneration of parts of the digestive tube of either male or female in the sense that any part ceases to be well organized or becomes disconnected from another part.
11. Nothing has been learned in connection with this study which throws any light upon the reasons for the peculiar life history of the cicada.

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IX. Index to Figures.

ac—anterior crop.
at—ascending intestine.
cm—circular muscles.
dt—descending intestine.
e—esophagus.
int—internal gland.
k—coil in ascending intestine.
kk—coil in descending intestine.
mt—malpighian vessels.
pc—posterior crop.
r—rectum.
x—junction of posterior crop with ascending intestine.
y—junction of malphigian vessel and intestine.

EXPLANATION OF PLATES.

Plate XXIII.

Fig. 1. Semidiagrammatic representation of ventral aspect of digestive system based upon dissections and reconstructions from sections. 10X.

Fig. 2. The same viewed from the left side.

Plate XXIV.

Fig. 3. Diagram of the digestive organs showing the relationships of the various parts and the course of the food stream.

Figs. 4, 5, 6. Diagrammatic figures of cross sections in anterior crop region showing probable method of complication resulting in intimate relation between anterior crop and "internal gland." Cf. Figs. 6 and 9.

Plate XXV.

Fig. 7. Frontal section through internal gland and anterior part of descending intestine.

Fig. 8. Vertical section through floor of anterior crop.

Fig. 9. Transverse section through forward part of internal gland, anterior crop and descending intestine.

Plate XXVI.

Fig. 10. Sagittal section showing junction of esophagus with anterior crop.

Fig. 11. Section through extreme anterior portion of posterior crop showing details of cell structure.

Fig. 12. Same slightly posterior to Fig. 11.

Fig. 13. Same midway between extremities of posterior crop.

Plate XXVII.

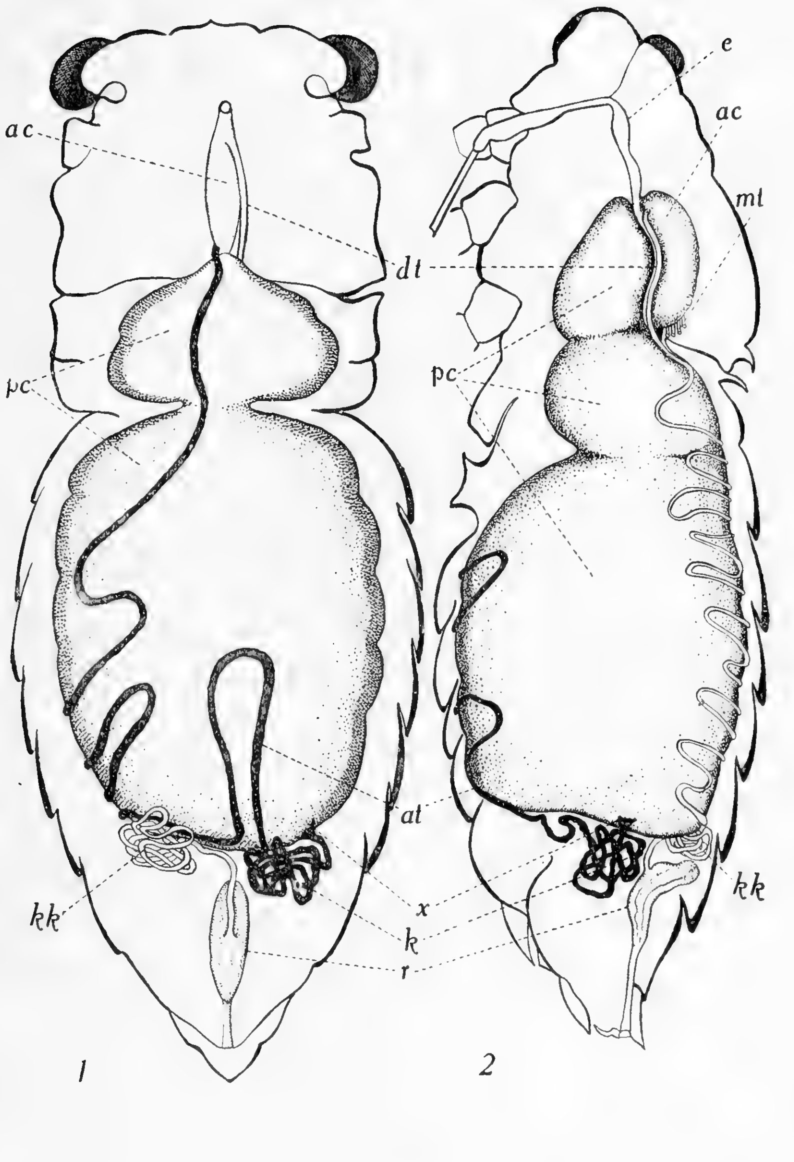
Fig. 14. Section showing junction of posterior crop and ascending intestine.

Figs. 15, 16, 17. Transverse sections through different parts of ascending intestine showing different phases of digestive activity.

Plate XYVIII.

Fig. 18. Transverse section through descending intestine at its anterior end.

Fig. 19. Same, midway between its extremities.



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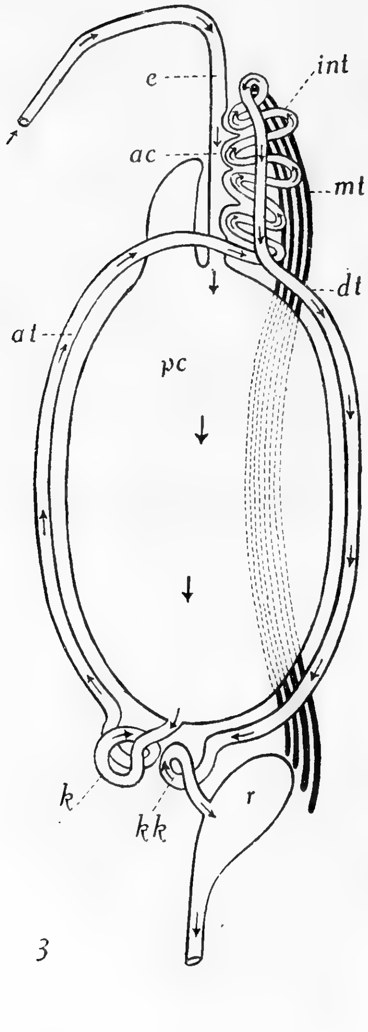

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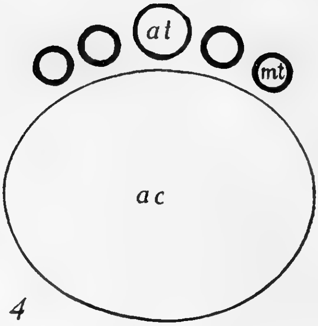

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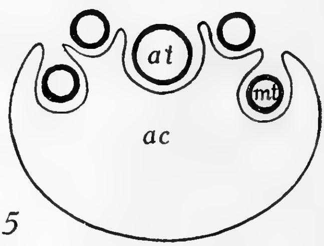

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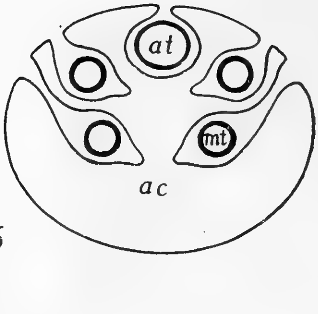

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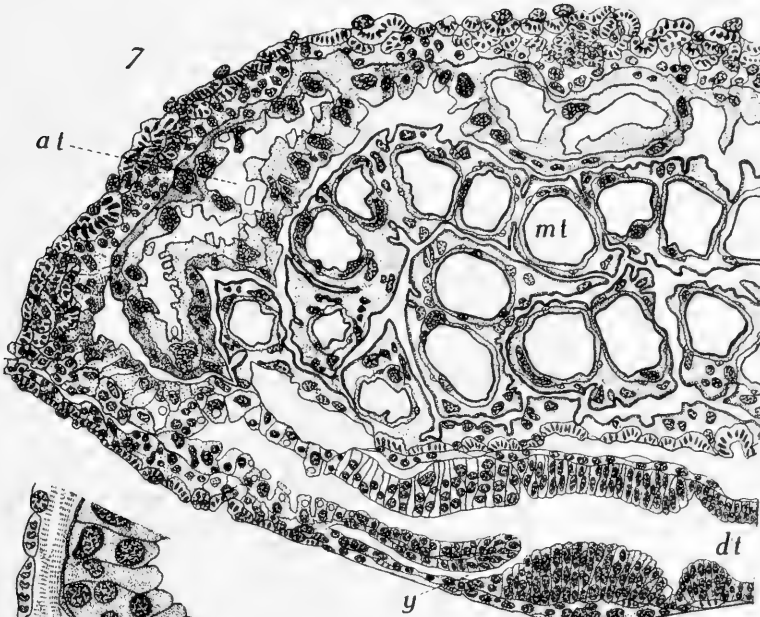
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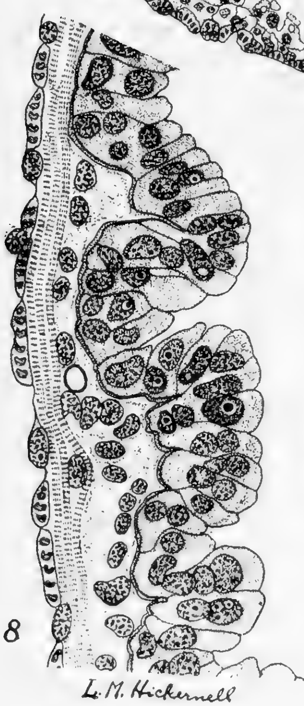
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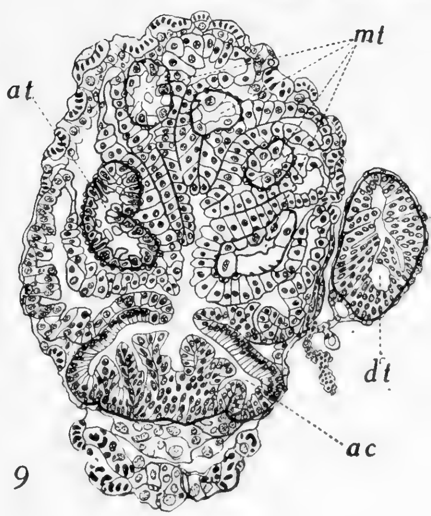
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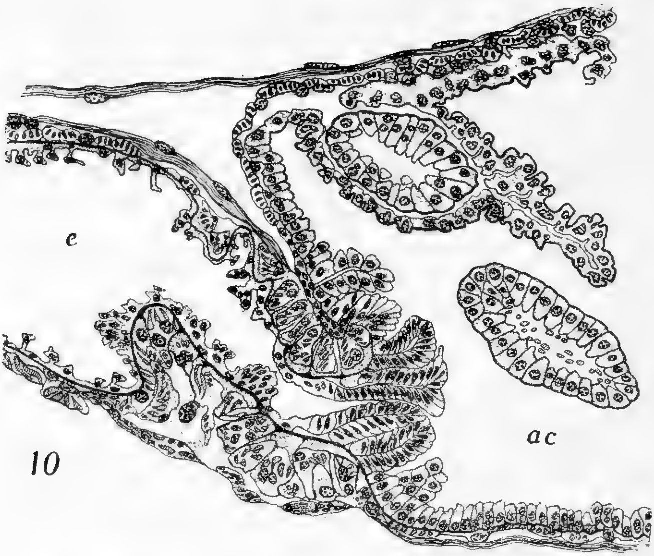

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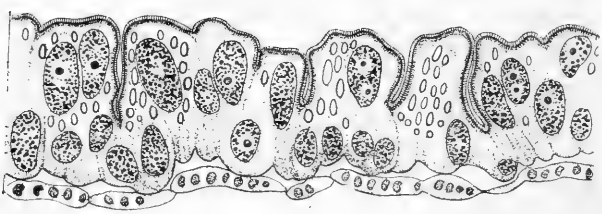

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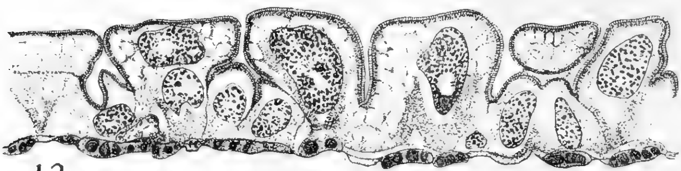

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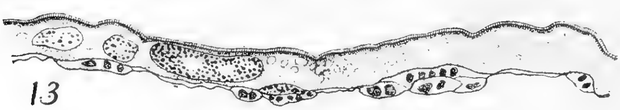

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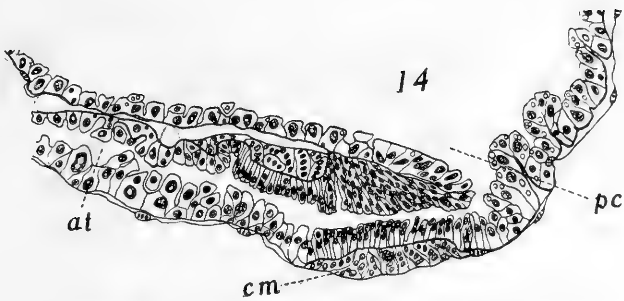

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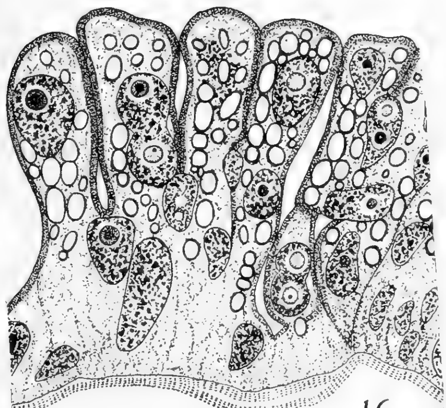

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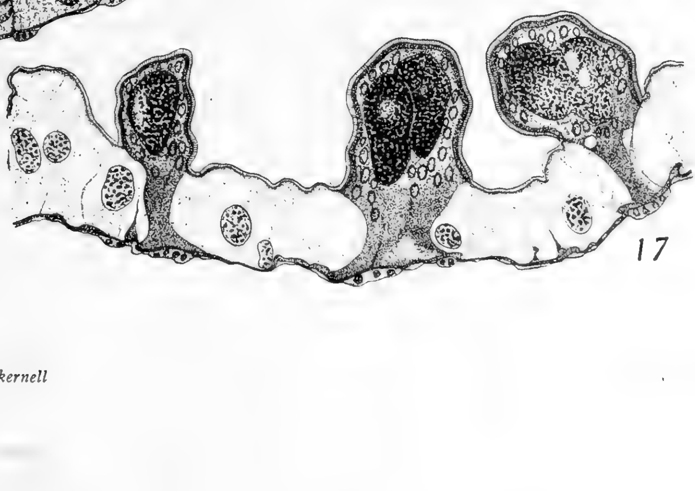

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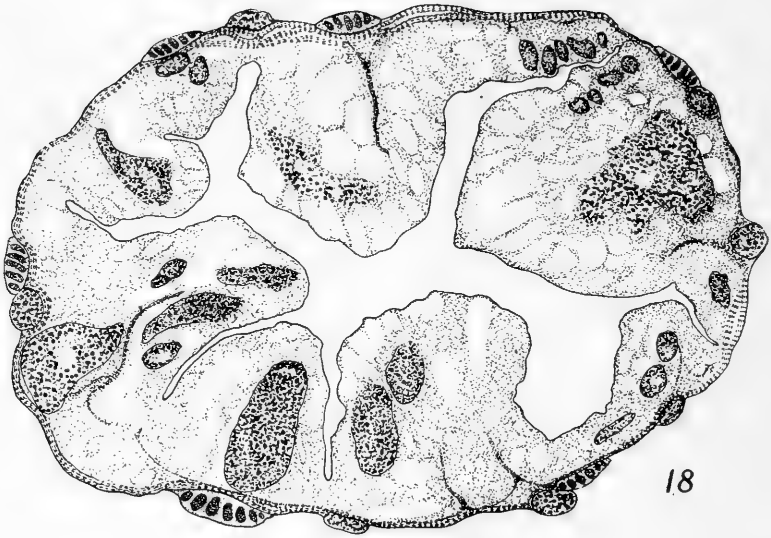

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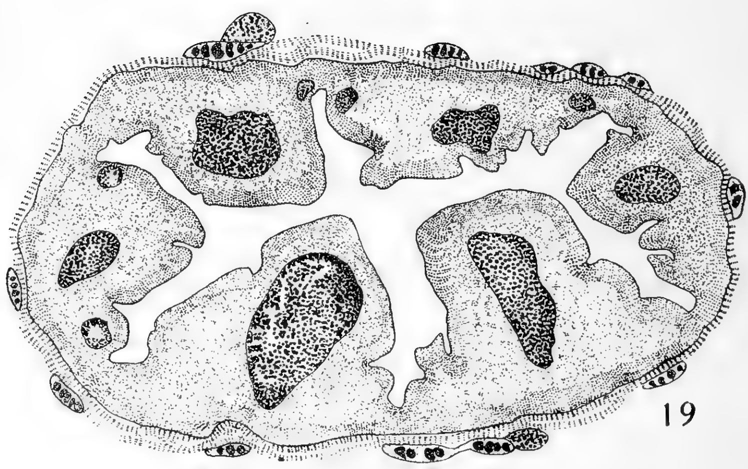

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ANNALS

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The Entomological Society of America

Volume XIII SEPTEMBER, 1920 Number 3

NEW OR LITTLE-KNOWN CRANE-FLIES FROM FORMOSA (TIPULIDÆ, DIPTERA).

CHARLES P. ALEXANDER.

During the past eight years, numerous important collections of crane-flies have been made in various parts of the island of Formosa so that now we have an excellent foundation for future work on this fauna. A large and valuable collection of Tipulidæ and Ptychopteridæ has recently been received from Dr. T. Shiraki, Chief of the Division of Entomology of the Agricultural Experiment Station of Formosa. Several species that are undescribed and a number of others that are still insufficiently known were contained in this material so that the collection amply merits a special report. The writer wishes to express his sincere thanks to Dr. Shiraki and his assistant entomologists for the privilege of studying this material. The types are preserved in the writer's collection.

The following altitudes of stations included in this paper were supplied by Dr. Shiraki: Arisan, about 8,000 feet; Funkiko, about 6,000 feet; Kanshiree, about 1,000 feet; Koshun, about 300 to 500 feet; Musha, about 3,700 feet; Noko, about 10,000 feet; Shinchiku (a prefecture; collecting done at 500 to 1,000 feet); Shishito, about 1,000 feet; Taito (a prefecture; collecting done at about 500 feet); Tappan, about 3,000 feet.

The high mountains of Formosa support a rich endemic crane-fly fauna, this including a curious union of Oriental and Holarctic genera. Besides the numerous endemic forms, a considerable number of additional species described from adjoining countries have been taken in Formosa. These include species described from Japan (Alexander), the Philippine

Islands (Bezzi), Sumatra and Java (Edwards, de Meijere and Alexander) and British India (Brunetti). The more important papers dealing with the crane-fly fauna of the island are the following:

Edwards, F. W. A Revision of the Tipulid Genus Styringomyia, Lw.; Trans. Ent. Soc. London, 1914, Part I, pp. 206-227, pl. 19-25, 1914.
Edwards, F. W. New and little-known Tipulidæ, chiefly from Formosa. Ann. Mag. Nat. Hist., ser. 8, vol. 18, pp. 245-269, pl. 12; September, 1916.
Enderlein, Gunther. Studien über die Tipuliden, Limoniiden, Cylindrotomiden und Ptychopteriden; Zool. Jahrb., Syst., vol. 32, pt. 1, pp. 1-88, 1912.
Matsumura, S. Thousand Insects of Japan. Additamenta II, pp. 185-474, pl. 16-25; July, 1916.
Riedel, M. P. H. Sauter's Formosa-Ausbeute. Nematocera Polyneura (Dipt.); Supplementa Entomologica, No. 1, pp. 26, 27; 1912.
Riedel, M. P. The same, part II; Entomologische Mitteilungen, vol. 2, no. 9, pp. 272-276; 1913.
Riedel, M. P. The same, part III; Archiv für Naturgeschichte, Abt. A, vol. 5, pp. 109-116; 1916 (August, 1917).
Riedel, M. P. The same, part IV, Liriopidae (Ptychopteridae) und Nematocera Polyneura (Dipt.); Annales Musei Nationalis Hungarici, vol. 16, p. 315-320; 1918.

So far as known, the Oriental crane-fly fauna is the richest of all the regions of the world. It is interesting to note that the known fauna of this region is even now far larger than that of either the much better known Palæarctic or Nearctic regions.

Libnotes Westwood.

Libnotes regalis Edwards.

1916. *Libnotes regalis* Edwards, Ann. Mag. Nat. Hist., ser. 8, vol. 18, p. 248.

One female, taken at Arisan, Formosa, June 22, 1917 (T. Shiraki) No. 1331.

This magnificent crane-fly has hitherto been known only from the type, a fragmentary specimen in the collection of the British Museum that from its size is judged to be a male. The female sex may now be described and additional details of color and structure indicated.

Allotype, ♀. Very similar to the description of the type. Rostrum and palpi dark brown. Antennæ moderately long for a member of this genus, dark brown, the apices of the flagellar segments indistinctly paler. Head greenish yellow. The supernumerary cross-veins of the wings are surrounded by conspicuous brown seams, the one in cell R_3 lying just proximad of r, the one in cell R_5 being almost in alignment with the outer deflection of M_3; r at the tip of R_1. The wing-markings described by Edwards as being black are here of a medium brown. Abdomen brownish testaceus, sternites paler, especially basally; a

narrow, dark brown lateral stripe on either side. Ovipositor as in the genus, the tergal valves comparatively small and strongly upcurved, the longer sternal valves almost straight, but slender.

Female. Length 12.8 mm.; wing, 17.8 mm.

Allotype, ♀, Arisan, Formosa, June 22, 1917.

Limnobia Meigen.

Limnobia atridorsum sp. n.

General coloration of the mesonotum shiny black; pleura yellowish, marked with black; wings brownish yellow, the cord indistinctly seamed with darker; abdominal tergites dark brown, sternites yellow, ringed caudally with dark brown.

Female—Length 9 mm.; wing, 9.1 mm.

Rostrum black, moderately elongated; palpi black. Antennæ of moderate length, the first scapal segment brownish black; second segment pyriform, yellowish; first flagellar segment obscure yellow basally, remainder of the flagellum black; flagellar segments cylindrical, with long, black verticils. Head strongly narrowed behind the eyes, shiny brownish black, the front and anterior part of the vertex gray pruinose; a median furrow on the occiput and posterior part of the vertex.

Pronotum black medially. Mesonotal praescutum shiny black, the humeral region conspicuously obscure yellowish; remainder of the mesonotum shiny black. Propleura orange-yellow; mesepisternum and mesosternum black; remainder of the pleura greenish yellow, with a rounded dark brown spot on the lateral sclerites of the postnotum immediately before the root of the halter. Halteres pale brown, the knobs dark brown. Legs with the fore coxæ and trochanters orange-yellow; remaining coxæ and the trochanters greenish yellow; rest of the legs broken. Wings brownish yellow; stigma dark brown; cord and outer end of cell *1st* M_2 narrowly and indistinctly seamed with brown; wing-tip indistinctly darkened; veins dark brown. Venation: *Sc* long, Sc_2 at the tip of Sc_1 and at least four times as long as Sc_1 alone, about equal to *r; Rs* moderately long, angulated and slightly spurred at origin; *r* removed from the tip of R_1 to a distance between one and one-half to two times its own length; cell *1st* M_2 closed, basal deflection of Cu_1 just beyond the fork of *M;* the costa continues around the wing-margin as a delicate vein.

Abdominal tergites dark brown; sternites yellow, the posterior margins of the segments narrowly ringed with dark brown, these bands increasing in size to the apical segments, on the sub-terminal segments including the entire sternite. Ovipositor with the tergal valves long, straight, acute; sternal valves shorter.

Habitat: Formosa. Holotype, ♀, Funkiko, April 25, 1917 (T. Shiraki) No. 1335.

Limnobia atridorsum is a species that might be referred with almost equal propriety to either *Limnobia* or *Dicranomyia*. Its closest relative seems to be *L. japonica* (Alexander) of Japan.

Dicranomyia Stephens.

Dicranomyia puncticosta Brunetti.

1912. *Dicranomyia puncticosta* Brunetti; Fauna Brit. India, Diptera Nematocera, pp. 377, 378, pl. 7, fig. 7.

A small series of both sexes from Funkiko, Formosa, April 21–29, 1917 (T. Shiraki) No. 1339.

Antocha Osten Sacken.

Antocha javanensis Alexander.

1915. *Antocha javanensis* Alexander, Proc. U. S. Nat. Mus., vol. 49, p. 171, pl. 43, fig. 18.

A small series of both sexes taken at Shishito, Formosa, May 25–26, 1917 (T. Shiraki) No. 1345. The specimens agree well with the type of *A. javanensis*, although there are, in some specimens, three feebly-defined brownish stripes on the praescutum. This is presumably the species mentioned by Edwards from Horisha, Formosa (Ann. Mag. Nat. Hist., ser. 8, vol. 18, p. 249), although the species is very much smaller than the European *A. vitripennis* (Meigen). The male sex has not been described and one of the present specimens is hereby designated as allotype.

Allotype, ♂. Male hypopygium with the dorsal pleural appendage cylindrical, chitinized, the apex truncated and with a small rounded notch; ventral appendage fleshy with numerous coarse bristles.

Male—Length 4–4.1 mm.; wing, 4.3–4.5 mm.

Allotype, ♂, Shishito, Formosa, May 25, 1917.

Styringomyia Loew.

Styringomyia flavitarsis sp. n.

General coloration shiny black; legs black, the posterior tarsi obscure yellow; wings dark brown.

Male—Length, 7.8 mm.; wing, 6.1 mm.

Rostrum and palpi dark brown. Antennal scape brownish black; basal flagellar segments dark brown, the remainder brownish yellow, the segments rather elongated. Head brownish testaceous.

Thoracic dorsum entirely shiny black. Pleura dark brown. Halteres brownish black. Legs with the coxæ black; trochanters obscure yellow; femora black, obscure yellow basally, this marking most extensive on the fore legs, almost obliterated on the posterior femora; tibiæ entirely black; tarsi of the fore legs black, the metatarsi slightly paler basally; posterior tarsi dull yellow, only the last segment blackened. Wings with a strong, dark brown tinge; a faintly darker cloud on *r-m;* veins brownish black. Venation: *2nd Anal* vein not angulated or spurred.

Abdomen black.

Habitat: Formosa. Holotype, ♂, Funkiko, April 27, 1917 (T. Shiraki) No. 1351.

The only species with which this large, vigorous *Styringomyia* may be confused is *S. solocipennis* (Enderlein) of Madagascar, a much smaller fly with the legs entirely dark brown.

Styringomyia flava Brunetti.

1911. *Styringomyia flava* Brunetti, Rec. Indian Mus., vol. 6, p. 301.

Three ♂ ♀'s, Funkiko, Formosa, April 21–27, 1917 (T. Shiraki) No. 1329.

Paratropeza Schiner.

Paratropeza (Gymnastes) hyalipennis sp. n.

Generally similar to *P. ornatipennis* (de Meijere); wings hyaline, without dark crossbands.

Male—Length 4.8 mm.; wing, 5.6 mm.

Rostrum and palpi brownish black. Antennæ brownish black, the scapal segments a little brighter. Head broad, shiny blue-black.

Mesonotum deep black, the praescutum and scutum with bluish reflections, the postnotum with faint purplish reflections. Pleura black, the mesopleura faintly grey pruinose; dorso-pleural membrane dull yellow. Halteres black, the apices of the knobs pale yellow. Legs with the coxæ brownish black; trochanters yellowish brown; only the posterior pair of legs remain; femora obscure brownish yellow, the swollen tips broadly dark brown, immediately before the brown tips a narrow yellowish ring; tibiæ yellow, the tips broadly blackened; metatarsi with the basal half yellow, the distal half and the remaining tarsal segments black. Wings hyaline, only the small, rounded stigma brown; veins dark brown. Venation almost as in *P. ornatipennis; r* on R_2 near the middle of its length; basal deflection of Cu_1 at or immediately before the fork of *M*.

Abdomen blue-black.

Habitat: Formosa. Holotype, ♂, Funkiko, April 25, 1917 (T. Shiraki) No. 1354.

Paratropeza (Gymnastes) ornatipennis (de Meijere).

1911. *Gnophomyia ornatipennis* de Meijere; Tijdschr. v. Ent., vol. 54, pp. 47, 48, pl. 3, fig. 34.

Three ♂ ♀, Funkiko, Formosa, April 21–29, 1917 (T. Shiraki) No. 1338.

Paratropeza (Gymnastes) shirakii sp. n.

Black, the front and vertex white; halteres with the knobs white; femora and tibiæ black, each with two narrow white rings; metatarsi white basally; wings brown, the base and two narrow crossbands whitish hyaline; *r-m* connecting with *Rs* before its fork.

Male—Length, 4.2–4.3 mm.; wing, 5 mm.

Female—Length, 5 mm.; wing, 5 mm.

Rostrum and palpi brown. Antennæ with the first segment whitish, remainder of the antennæ dark brownish black. Front and anterior part of the vertex snowy white, the latter slightly protuberant; remainder of the head black, sparsely gray pruinose.

Thorax black. Halteres dark brown, the knobs and extreme ends of the stem whitish. Legs with the coxæ and trochanters black; femora black, a narrow ring beyond mid-length and the narrow tip white; tibiæ black, a narrow ring immediately beyond the base and a subequal ring beyond midlength white; metatarsi with the basal half white; remainder of the tarsi black; posterior femora clavate as in this group of species. Wings dark brown, the base up to the arculus, a very narrow crossband before the cord and a subequal similar band at the outer end of cell *1st* M_2 whitish hyaline; the first of these bands does not include cells *C* and *Sc*, but the outer band extends from margin to margin. Venation: *r* not with the apparent fork, as in *ornatipennis*, inserted on R_{2+3} about its own length beyond the fork; *r-m* connecting with *Rs* before its fork; basal deflection of Cu_1 at the base of the very narrow cell *1st* M_2.

Abdomen blue-black; in the female, the valves of the ovipositor are light horn-colored.

Habitat: Formosa. Holotype, ♂, Funkiko, April 21, 1917 (T. Shiraki). Collectors No. 1354. Allotopotype, ♀. Paratopotype, ♂.

This exquisite little fly is dedicated to its collector, Dr. T. Shiraki. It is most nearly related to *P. bistriatipennis* (Brunetti) of South-western India, differing in the uniformly black thorax and the very different leg-pattern.

Atarba Osten Sacken.

Atarba pallidicornis Edwards.

1916. *Atarba pallidicornis* Edwards, Ann. Mag. Nat. Hist., ser. 8, vol. 18, pp. 249, 250.

Six males and females, Funkiko, Formosa, April 21–27, 1917 (T. Shiraki) No. 1342. Only the female sex has been described. Edwards is entirely right in stating that the tibial spurs in this and the following species are lacking. This is a very strange condition, though entirely duplicated in the genus *Polymera* and in *Lecteria* (if we consider *Psaronius* Enderlein as being a spurred form of this genus). The new subgeneric name, *Atarbodes*, may be applied to the group of species with spurless tibiæ, the type of the subgenus being the present form.

Allotype, ♂. Very similar to the female. Antennæ short, with long, conspicuous verticils, longest on the basal segments of the flagellum. Abdomen with a barely indicated subterminal brown ring. Hypopygium with the outer pleural appendage densely set with appressed blackened spines; inner appendage a little longer, flattened, pale, at the apex with a few hyaline setæ.

Male.—Length 4.5–4.8 mm.; wing, 5.8–6 mm.

Allotype, ♂, Funkiko, Formosa, April 27, 1917.

Atarba fuscicornis Edwards.

1916. *Atarba fuscicornis* Edwards, Ann. Mag. Nat. Hist., ser. 8, vol. 18, p. 250.

One female, Funkiko, Formosa, April 21, 1917 (T. Shiraki) No. 1349.

Erioptera Meigen.

Erioptera alboguttata Edwards.

1916. *Erioptera* (*Erioptera*) *alboguttata* Edwards; Ann. Mag. Nat. Hist., ser. 8, vol. 18, p. 252, pl. 12, fig. 4.

One male from Funkiko, Formosa, April 29, 1917 (T. Shiraki) No. 1356. As pointed out by its describer, this interesting crane-fly bears a striking resemblance to species of the subgenus *Mesocyphona*, especially *E.* (*M.*) *dulcis* and *E.* (*M.*) *needhami*, but is a true member of *Erioptera* in the restricted sense.

Erioptera (Empeda) nigroapicalis sp. n.

Size moderately large (wing over 4 mm.); head gray; femora yellow, the tips broadly and conspicuously brownish black; wings subhyaline, veins brown; male hypopygium with the outer pleural appendage heavily chitinized, blackened.

Male.—Length 3.2 mm.; wing, 4.5 mm.

Female.—Length 4 mm.; wing, 4.7 mm.

Rostrum and palpi reddish. Antennæ with the first scapal segment grayish pruinose; second segment enlarged, black; first flagellar segment

enlarged, subequal to the second scapal segment in size, black; remainder of the flagellum reddish brown; verticils of moderate length only. Head light bluish-gray.

Mesonotal praescutum obscure yellowish-brown, with three broad black stripes, the lateral stripes continued caudad onto the scutal lobes, the median stripe best indicated anteriorly; remainder of scutum dark gray pruinose; scutellum and the posterior margins of the scutal lobes obscure yellow; postnotum black, sparsely gray pruinose. Pleura yellowish, the mesopleura and lateral sclerites of the postnotum darker and faintly grayish pruinose. Halteres bright yellow. Legs with the coxæ and trochanters yellow; femora yellow, the tips broadly and conspicuously brownish black; tibiæ and metatarsi dull yellow, the tips narrowly dark brown; remainder of the tarsi dark brown; tibiæ and first two tarsal segments each with two powerful bristles close to the tip on the ventral face. Wings nearly hyaline; veins brown. Venation: *Sc* short, ending a short distance beyond the origin of *Rs; r* more than its own length beyond the fork of *Rs;* R_2 rather short, oblique; cell *1st* M_2 open by the atrophy of *m*.

Abdomen reddish brown. Male hypopygium with the pleurites produced into a small fleshy lobe; pleural appendages two in number, the outer appendage bifid, heavily blackened, the two arms almost straight, approximately subequal in length, but one much stouter than the other; inner pleural appendage a pale arm that is slightly expanded distally. Ovipositor with the tergal valves considerably longer than the sternal valves, slightly upcurved.

Habitat: Formosa. Holotype, ♂, Funkiko, April 29, 1917 (T. Shiraki) No. 1353. Allotopotype, ♀, April 21, 1917. Paratopotypes, 3 ♂'s, 1 ♀, April 21–29, 1917.

Erioptera (Empeda) minuscula sp. n.

Size very small (wing under 3.5 mm.); head gray; femora yellowish, the tips rather broadly infuscated; wings subhyaline; veins pale brown; male hypopygium with the pleural appendages not blackened.

Male.—Length 2.2 mm.; wing, 3 mm.

Female.—Length 2.8 mm.; wing, 3.3 mm.

Rostrum and palpi dark brown. Antennæ dark brown, the verticils in the male elongate. Head light gray.

Mesonotum reddish brown to dark liver-brown, deepest on the anterior part of the praescutum; lateral margins of the praescutum narrowly yellowish. Pleura reddish, sparsely gray pruinose. Halteres yellow. Legs with the coxæ reddish yellow; trochanters brownish yellow; femora obscure yellow, the tips rather broadly infuscated; tibiæ and metatarsi obscure yellow, the tips weakly infuscated; remainder of tarsi dark brown; two conspicuous bristles before the tips of the tibiæ and first two tarsal segments. Wings subhyaline; veins pale brown; stigma lacking. Venation: R_2 not conspicuously oblique; *Sc* ending about opposite one-fifth the length of *Rs*; cell *1st* M_2 open by the atrophy of *m*.

Abdomen reddish brown. Male hypopygium with the pleural appendages not blackened as in *E. nigroapicalis*, the outer appendage bifid, the caudal arm acute, the cephalic arm shorter, shaped as a flattened blade; inner pleural appendage slender, cylindrical. Ovipositor with the valves long and slender, pale, the tergal valves moderately upcurved.

Habitat: Formosa. Holotype, ♂, Shishito, May 25, 1917 (T. Shiraki) No. 1357. Allotopotype, ♀. Paratopotypes, 2 ♂'s, 1 ♀.

Molophilus Curtis.

Molophilus costalis Edwards.

1916. *Molophilus costalis* Edwards; Ann. Mag. Nat. Hist., ser. 8, vol. 18, p. 251.

One ♂, one ♀, Funkiko, Formosa, April 25–27, 1917 (T. Shiraki) No. 1355.

Allotype ♂. Very similar to the type female. Antennæ of moderate length only. Hypopygium with four conspicuous blackened spinous appendages that are almost straight; dorsal spines at their base on the inner side with a smaller, straight spine of approximately one-half the length of the larger. The ventral appendages are longer and more slender, the tips acute, the inner face before the tip with microscopic teeth.

Male—Length 3.2 mm.; wing, 4 mm.

Allotype, ♂, Funkiko, Formosa, April 27, 1917.

Gonomyia Meigen.

Gonomyia (Gonomyia) pruinosa sp. n.

General coloration of the head and thorax dark, heavily light gray pruinose; antennæ dark brown, the scapal segments pale whitish yellow; legs brownish yellow, metatarsi short; wings nearly hyaline, the stigma and small dots at the origin of *Rs* and the fork of *Cu* dark brown; cell *1st* M_2 open; basal deflection of Cu_1 far before the fork of *M;* abdomen brownish black, the tergites narrowly ringed with light yellow.

Female—Length, 5.6 mm.; wing, 5.2–5.3 mm.

Rostrum and palpi dark brown. Antennæ with the scapal segments pale whitish yellow, the flagellar segments dark brown, oval. Head pale brown, heavily light gray pruinose.

Mesonotal praescutum with four dark brown stripes, heavily light gray pruinose, more reddish in the vicinity of the conspicuous, elongate pseudosutural foveæ. Pleura and sternum reddish yellow. Halteres elongate, pale brown, the knobs more yellowish. Legs with the coxæ and trochanters reddish yellow; femora and tibiæ brownish yellow, the tips of the latter narrowly darkened; tarsi brown. Wings nearly hyaline; stigma small, oval, dark brown; a small, dark brown spot at

the origin of *Rs* and another at the fork of *Cu;* veins dark brown, veins *C* and *Sc* yellowish. Venation: *Sc* rather short, ending just beyond the origin of *Rs; Rs* long, arcuated; R_3 a little shorter than *r-m;* R_{2+3} shorter than R_3; inner ends of cells R_3, R_5 and *1st* M_2 in alignment; cell *1st* M_2 open by the atrophy of the outer deflection of M_3; cell *2nd* M_2 longer than its petiole; basal deflection of Cu_1 more than its own length before the fork of *M*.

Abdomen dark brownish black, the tergites narrowly ringed caudally with light yellow, the lateral margins more broadly but obscurely yellow. Ovipositor with the tergal valves long and slender, gently upcurved.

Habitat: Formosa. Holotype, ♀, Shishito, May 26, 1917 (T. Shiraki) No. 1346. Paratopotype, ♀.

Gnophomyia Osten Sacken.

Gnophomyia (**Dasymallomyia**) **signata** (Brunetti).

1911. *Dasymallomyia signata* Brunetti; Rec. Indian Mus., vol. 6, p. 304.

One female, Funkiko, Formosa, April 25, 1917 (T. Shiraki) No. 1329. It is with deference to the views of Brunetti and Edwards that the name *Dasymallomyia* is here retained as a subgenus. In the opinion of the writer, the group rests on a very slim basis.

Limnophila Macquart.

Limnophila (**Dicranophragma**) **formosa** sp. n.

Close to *L. pulchripennis;* wings with a brown cross-banded pattern, including seven costal blotches, the third and fourth united into a V-shaped marking that continues caudad along the cord; a seam on *r* that continues to vein R_3.

Male—Length 4.8–5 mm.; wing, 6.3 mm.

Closely related to *L. pulchripennis* (Brunetti) of India (Fauna British India, Diptera Nematocera, pp. 524, 525; 1912), but differing in the details of coloration.

Rostrum and palpi brown. Antennal scape brown; flagellum light yellow, only the distal segments more testaceous. Head gary, yellowish pollinose.

Mesonotal praescutum pale, heavily yellowish pollinose, the remainder of the mesonotum more brownish. Pleura and sternum brown, light gray pruinose. Halteres yellow. Legs with the coxæ brown; trochanters obscure yellow; remainder of the legs yellow, the terminal tarsal segments brown. Wings yellowish subhyaline, with a cross-banded brown pattern; the more conspicuous markings along costa are as follows: A broad stripe near the wing-base, attaining vein *Cu*; a similar stripe at the origin of *Rs*, reaching *M;* a V-shaped mark, the proximal arm at Sc_2, the distal arm beyond the tip of R_1 con-

tinued proximad along R_{2+3}, uniting with the proximal arm at the fork of *Rs* and thence continued caudad as a broad seam along the cord; the distal arm is united along R_1 with a mark that surrounds *r* and continues caudad to vein R_3; a band at the level of the supernumerary cross-vein in cell R_2, extends from costa to the caudal margin of the wing at the end of vein M_3, paler and less distinct in the posterior cells; pale brown clouds at the ends of all the longitudinal veins; a brown seam along the outer end of cell *1st* M_2; a distinct grayish tinge in cells *M* and *Cu* beyond the base; two or three small brown dots in cell *2nd A* at the wing-margin.

Abdomen obscure yellow, the tergites margined laterally and posteriorly with dark brown. Hypopygium light brown.

Habitat: Formosa. Holotype, ♂, Funkiko, April 21, 1917 (T. Shiraki) No. 1341. Paratopotypes, 2 ♂'s, April 21–29, 1917.

Eriocera Macquart.

Eriocera sauteriana Enderlein.

1912. *Eriocera sauteriana* Enderlein; Zool. Jahrb., Syst., vol. 32, pt. 1, pp. 42, 43, fig. Y.

One male, Kanshiree, Formosa, June 15, 1917 (T. Shiraki) No. 1319.

Eriocera lygropis sp. n.

Size large (wing of male 19 mm. or over); general coloration deep velvety black; wings dark brownish black; cell M_1 present; abdomen with the bases of the segments shiny steel blue.

Male—Length 19 mm.; wing, 19–19.5 mm.

Rostrum and palpi dark brownish black. Antennæ short, dark brown. Head black, the front and anterior portion of the vertex sparsely gray pruinose; vertical tubercle conspicuous, directed cephalad.

Mesonotal praescutum velvety black with four shiny blackish stripes, the intermediate pair narrowly separated; lateral margins of the sclerites more brownish; remainder of the thorax deep black. Halteres short, black. Legs entirely deep black. Wings dark brownish black, more saturated along the costal margin, paler in the centers of the posterior and anal cells; veins brown. Venation: Sc_1 ending opposite *r*; Sc_1 alone longer than R_{2+3}; *r* far from the tip of R_1 and at about one-third the length of R_2; R_{2+3} a little longer than the deflection of R_{4+5}, the latter in alignment with the distal section of this vein; petiole of cell M_1 but little shorter than the fork; cell *1st* M_2 about as long as the petiole of cell M_1; basal deflection of Cu_1 near mid-length of cell *1st* M_2.

Abdomen deep velvety black, the base of each segment shiny steel-blue, broadest on segment two, those on the posterior segments becoming narrowed, on the sixth and seventh segments occupying the basal third of the segment or less.

Habitat: Formosa. Holotype, ♂, Koshun, April 25–May 25, 1918 (J. Sonan, K. Miyake, M. Yoshino). Paratopotype, ♂; homotypes, 3 specimens in the collection of the British Museum.

Eriocera lygropis (Greek, "gloomy") is closely allied to *E. unicolor* de Meijere, of Sumatra and was determined as such by Edwards in his report on Formosan Tipulidæ (Annals and Magazine of Natural History, ser. 8, vol. 18, p. 253; 1916). Subsequently Mr. Edwards and the writer have come to doubt that the two species are identical and specimens from the British Museum were sent to Dr. de Meijere by Mr. Edwards for comparison with the type of *unicolor*. Dr. de Meijere reports as follows: "The most conspicuous difference is that in your species there are broad shining bands on the abdomen, while in mine the abdomen is practically wholly dull black. The thorax of my species is more shining, on the part before the suture there are only three thin dull lines and also the hinder part is more shining. Your species is somewhat larger and the wings are broader, the end of *Rs* is nearer the wing-apex, the fork of R_{2+3} and the discoidal cell are somewhat shorter, the latter more quadrate." I would express my indebtedness to Mr. Edwards and Dr. de Meijere for thus clearing the identity of this large and conspicuous crane-fly.

Tricyphona Zetterstedt.

Tricyphona formosana sp. n.

General coloration light brown; legs pale brownish testaceous; wings subhyaline; vein R_2 long, oblique in position; cell *1st* M_2 open.

Male—Length about 4 mm.; wing, 5.8 mm.

Rostrum reddish brown; palpi brownish black. Antennæ comparatively short, dark brown, the first scapal segment obscure brownish yellow; flagellar segments oval. Head light brown, sparsely pruinose.

Mesonotal praescutum light brown, indistinctly transversely irrorate with short brown lines, sparsely pruinose; remainder of the mesonotum concolorous, the caudal margin of the postnotum darkened. Pleura obscure yellowish. Halteres pale brownish white. Legs with the coxæ yellow; trochanters testaceous; remainder of the legs pale brownish testaceous, the outer tarsal segments darkened. Wings subhyaline, the region of the stigma faintly darkened; veins pale brown. Venation: The free portion of R_2 equal to $R_{1+}R_2$, oblique in position, somewhat resembling the condition found in *T. protea* Alex.; *r-m* inserted at about mid-length of R_{4+5}; cell *1st* M_2 open by the atrophy of *m;* cell M_1 present; basal deflection of Cu_1 inserted on M_3 about one-half its own length beyond the fork of *M*.

Abdomen light brown; the first tergite darker medially; segments five and six somewhat darker colored.

Habitat: Formosa. Holotype, ♂, Arisan, April 24, 1917 (T. Shiraki) No. 1348.

Dictenidia Brullé.

Dictenidia formosana sp. n.

General coloration yellow, the mesonotum shiny black; posterior legs larger than the others, the tibia with a brown ring before mid-length and with the tips broadly dark brown; wings yellowish, the apex narrowly dark brown.

Male—Length about 11.5 mm.; wing, 11.6 mm.

Frontal prolongation of head and palpi yellow. Antennæ with the scapal segments yellow, the flagellum brown, the segments indistinctly darker basally. Head light yellow; vertex obscure yellow with a T-shaped black mark, the arms of the T passing to the eyes, the stem continued caudad on to the occiput.

Mesonotum obscure brownish yellow, the praescutum and scutal lobes shiny black. Pleura yellow. Halteres yellow, the knobs brown. Legs with the coxæ and trochanters yellow; fore and middle legs light yellowish brown, the tarsi darker; posterior legs much longer and stouter, the tibiæ yellow with a broad, dark brown ring before mid-length and with the tips rather broadly brownish black; tarsi brownish black. Wings with a strong yellowish tinge, deepest basally and in the costal region, more grayish in the posterior and anal cells; wing-tip brown, this occupying the ends of cells R_2 to M_1; stigma rather small, sub-rectangular, dark brown; a faint dark seam along the cord, most evident on the basal deflection of R_{4+5}, *r-m* and the basal deflection of Cu_1; veins dark brown; numerous macrotrichiæ in the apices of cells R_3 to M_1, confined to the central portions of the cells.

Abdomen obscure yellow, the tergites with an interrupted dorso-median stripe; segments eight and nine shiny black. Hypopygium cylindrical, not conspicuously enlarged.

Habitat: Formosa. Holotype, ♂, Funkiko, April 25, 1917 (T. Shiraki) No. 1329.

Dictenidia formosana is much more nearly allied to the genotype, *D. bimaculata* (Linnæus) of Europe than to *D. fasciata* Coquillett of Japan. It is readily told from *bimaculata* by the coloration of the posterior legs and the great reduction in the size of the dark band along the cord of the wing. Mr. Edwards informs me that *D. horikawæ* Matsumura is a *Pselliophora* rather than a *Dictenidia*. None of the dozen species of the former genus known to the writer possesses macrotrichiæ in the apical cells of the wing, a condition that is well defined in all

three species of *Dictenidia*, least extensive in *D. bimaculata*, where it is confined to cell R_5, most extensive in *D. fasciata* where macrotrichiæ are found in cells R_2, R_3, R_5 and M_1.

Pselliophora Osten Sacken.

Pselliophora ctenophorina Riedel.

1913. *Pselliophora ctenophorina* Riedel; Entomol. Mitteilungen, vol. 2, pp. 274-276.

One male from Taito, Formosa, February 25–March 27, 1919 (S. Inamura, J. Sonan and M. Yoshino) No. 1318.

One female from the type-locality (Koshun), April 25–May 25, 1918 (J. Sonan, K. Miyake and M. Yoshino).

In the male the last segment of the palpus is yellowish white, passing into dark brown at the narrow apex; in the female, however, the terminal palpal segment is entirely black, the third black with the extreme base and apex pale. In the male, the centers of the wing-cells are but slightly paler than the obscure blackish ground-color; in the female the centers of cells *M*, R_5, M_1, *2nd* M_2, M_4, *Cu*, Cu_1, *1st A* and *2nd A* are whitish hyaline.

Pselliophora scalator sp. n.

Closely related to *P. taprobanes* (Walker); thoracic pleura yellow; wings yellow with dark brown markings; abdomen with a dark brown median stripe, the posterior margins of the segments narrowly blackened.

Male—Length 17 mm.; wing, 15.8 mm.

Female—Length 20 mm.; wing, 17.5 mm.

Frontal prolongation of the head very short, yellow; palpi with the basal three segments yellow, the terminal segment dark brown at either end, paler brown medially. Antennæ of the male with the first segment obscure yellow, darker above; remaining segments bicolorous, the basal two-thirds of each segment and the pectinations black, the apical third yellow. In the female, the simple antenna is almost uniformly brown throughout. Head yellow, clothed with long, black hairs.

Pronotum yellow, the sides of the scutum narrowly margined with dark brownish black behind. Mesonotal praescutum yellow, with three conspicuous, dark brown stripes, the lateral stripes continued across the suture and re-appearing as conspicuous marks on the scutal lobes; remainder of the mesonotum yellow, the median areas of both scutellum and postnotum indistinctly darkened. Pleura yellow. Halteres brownish yellow, the knobs dark brown on the basal half. Legs with the coxæ orange-yellow; trochanters yellow; femora brownish yellow, the posterior femora narrowly tipped with black; tibiæ brown, the posterior tibiæ darker brown, with a broad, pale yellow ring just beyond the base; tarsi dark brown. Wings yellowish, variegated with dark brown; the wing-tip beyond the cord is dark brown, in the male, the centers of cells

R_2, R_3, R_5, M_1 and *2nd* M_2 indistinctly paler; a broken X-shaped cross-band of brown before the cord extending from the subcostal cell to the posterior margin of the wing; the amount of yellow in cell R enclosed between the upper arms of the X is variable, more extensive in the female, very restricted in the male; the posterior arms of the X enclose a solid area in both sexes; cells *1st A* and *2nd A* are largely brown, this appearing as a broad seam on vein *2nd* A and along the posterior margin of cell *2nd A*, most intense in the extreme anal angle; in the end of cell R, the yellow ground-color is much paler, nearly hyaline; veins dark brown. Venation: Cell M_1 sessile.

Abdominal tergites yellow, with a broad, conspicuous, dark brown median stripe that is narrowly interrupted at the anterior margin of each segment, at the posterior margin uniting with a narrow, black, posterior border; last segment brownish black; sternites similar, but the median stripe is reduced to a series of linear dashes. Ovipositor with the basal sclerite jet-black; valves slender, deep horn-colored.

Habitat: Formosa. Holotype, ♂, Taito, February 25–March 27, 1919 (S. Inamura, J. Sonan and M. Yoshino) No. 1320.Allotype, ♀, Shinchiku, July 1–30, 1918 (J. Sonan and K. Miyake).

This is presumably the species reported from the island as *Pselliophora taprobanes* (Walker) by Riedel (Arch. für Naturgeschichte, Abt. A, vol. 5, p. 115; 1917; Ann. Musei Nat. Hungarici, vol. 16, p. 320; 1918).

Brithura Edwards.

Brithura conifrons Edwards.

1916. *Brithura conifrons* Edwards, Ann. Mag. Nat. Hist., ser. 8, vol. 18, pp. 263, 264.

One female, taken at Arisan, Formosa, October 2–23, 1918 (J. Sonan and M. Yoshino) No. 1334.

Up to the present date, only the male sex of members of this curious genus have been discovered. The female of *B. conifrons* is hereby designated as allotype and may be further discussed as follows:

Allotype, ♀. Very similar to the description of the male. The vertical cone is very conspicuous as in the male. The second scapal segment is conspicuously brighter-colored than the first, yellowish. Praescutal interspaces with an abundant erect pubescence. Abdomen dark brown; eighth and ninth segments rufous. Ovipositor orange-yellow, the tergal valves almost straight, acute; sternal valves shorter, straight, a little higher than the tergal valves.

Female—Length about 25 mm.; wing, 20 mm.; abdomen, 15.4 mm.; Fore leg, femur, 9 mm.; tibia, 10.5 mm.; metatarsus, 6.2 mm.; Middle leg, femur, 10 mm.; tibia, 9.6 mm.; metatarsus, 8 mm.; Hind leg, femur, 11.5 mm.; tibia, 12.3 mm.; metatarsus, 10 mm.

Allotype, ♀, Arisan, Formosa, October 2–23, 1918.

Tipula Linnæus.

Tipula holoserica (Matsumura).

1916 (July). *Formotipula holoserica* Matsumura, Thousand Insects Japan, Add. 2, pp. 456, 457.

1916 (September). *Tipula rufomedia* Edwards, Ann. Mag. Nat. Hist., ser. 8, vol. 18, pp. 259, 260.

1917. *Tipula nigrorubra* Riedel, Arch. für Naturgeschichte, Abt. A, vol. 5, pp. 115, 116.

One male from Edwards' type-locality, Horisha, 1916, No. 1332. One male, Shinchiku, Formosa, July 1–30, 1918 (J. Sonan and K. Miyake). Riedel describes the legs of his species as being "powerful," but in spite of this discrepancy, there can be no reasonable doubt of the synonymy.

Tipula shirakii Edwards.

1916. *Tipula shirakii* Edwards, Ann. Mag. Nat. Hist., ser. 8, vol. 18, pp. 258, 259.

Six ♂ ♀, Funkiko, Formosa, April 21–27, 1917 (T. Shiraki) No. 1327. This series of specimens agrees well with Edwards' characterization of the type. The additional details of structure of the hitherto unknown male may be given.

Allotype, ♂. Very similar to the female, differing only in the sexual characters. The antennæ are short. Hypopygium with the ninth tergite large, nearly quadrate, with a conspicuous, flattened median lobe that is deeply notched medially, the lateral lobules thus formed being compressed blades that are covered with abundant black spicules. Outer pleural appendage large, flattened, broad basally, gradually narrowed to the rounded apex, pale yellowish white and very conspicuous. From the ventral-caudal angle of the ninth pleurite, close to the ninth sternite, two conical appendages hang in the notch of the ninth sternite, these provided with a pencil of long, reddish bristles at their tips. Ninth sternite strongly carinate. Eighth sternite somewhat projecting, the median area unarmed, on either side of the median area with a dense fringe of moderately long silvery bristles.

Male—Length 17–18 mm.; wing, 20–24 mm.

Allotype, ♂, Funkiko, Formosa, April 21, 1917.

Tipula tridentata sp. n.

Head gray; pronotum cream-colored, with a dark brown median line; mesonotal praescutum obscure brownish black, sparsely pruinose; wings strongly brownish yellow, the anal cells slightly paler; abdomen brownish yellow, with three black longitudinal stripes; male hypopygium with the ninth tergite tridentate, with an acute median tooth and more blunt lateral lobes; eighth sternite with three tufts of yellowish setæ.

Male—Length 11.5 mm.; wing, 14.2 mm.

Frontal prolongation of the head dark gray above, brownish yellow beneath, these two colors divided by a narrow dark brown line; palpi dark brown. Antennæ moderately elongated, the long first scapal segment dark brown, indistinctly reddish at the tip; second scapal segment reddish brown; flagellum dark brownish black, with a heavy white pubescence; flagellar segments with the basal enlargement moderately prominent, verticils conspicuous. Head light gray.

Pronotum cream colored with a delicate, dark brown, median line. Mesonotal praescutum obscure brownish black, sparsely pruinose, without distinct stripes, the margins of the sclerite more brownish; scutal lobes black, sparsely pruinose; scutellum reddish brown, the median sclerite with a delicate, dark brown, median line; postnotum gray, whitish gray pruinose. Pleura pale brown, sparsely gray pruinose. Halteres rather long, light yellow, the knobs brown. Legs with the coxæ light yellow, with a faint gray bloom; trochanters dull yellow; fore femora brown, more yellowish basally; posterior femora brownish yellow, with a narrow, dark brown ring before the tip; tibiæ brown, the tips dark brown; tarsi dark brown. Wings with a strong, brownish yellow tinge that is slightly paler in the anal cells; stigma slightly darker brown; a small obliterative area before the stigma in cell *1st* R_1 and another extending from the end of cell R across cell *1st* M_2 into the base of cell M_4; veins dark brown; three or four macrotrichiæ in cell R_5 near its distal end. Venation: Rs about twice the length of R_{2+3}; basal section of R_2 nearly perpendicular to the end of R_{2+3}; cell *1st* M_2 small, pentagonal; petiole of cell M_1 about one-half the length of the cell; *m-cu* present.

Abdomen brownish yellow, the tergites with three conspicuous black longitudinal stripes; sternites and hypopygium pale brownish yellow. Male hypopygium with the ninth tergite extensive, the caudal margin produced into two, bluntly rounded, lateral lobes and an acute median tooth that is carinate on its ventral surface; margins of all three lobes heavily blackened. Ninth pleurite complete; outer pleural appendage slender, elongate, slightly flattened, broadest at about mid-length, the distal two-thirds provided with long, coarse, black setæ; inner pleural appendage complex, the posterior margin at the base produced into a cylindrical lobe that tapers to the subacute apex and is clothed with long setæ. Ninth sternite with a comparatively shallow notch, from between which project the small, curved, black apophyses. Eighth sternite rather projecting, the caudal margin trilobed, a rounded median lobe that bears a flattened fringe of yellow hairs and two nearly

similar lateral lobes that bear pencils of long, yellow hairs, these pencils directed across the median line so as to lie almost in a straight line or very broadly decussate.

Habitat: Formosa. Holotype, ♂, Musha, May 18–June 15, 1919 (T. Okuni, J. Sonan, K. Miyake and M. Yoshino).

Tipula subapterogyne sp. n.

Belongs to the *arctica* group; allied to *T. serricauda* Alexander; praescutal stripes brownish black, much darker than the markings on the remainder of the mesonotum; wings of the female semi-atrophied.

Male—Length, 15.5 mm.; wing, 21.2–21.5 mm.

Female—Length about 20 mm.; wing, 6.8 mm.

Frontal prolongation of the head gray, more reddish laterally; nasus very long and slender; palpi brownish black, rather short. Antennæ with the basal segment reddish, gray pruinose; second segment light yellow; flagellum black; antennæ of the male of moderate length. Head yellowish gray, more rufous adjoining the inner margins of the eyes; a narrow, dark brown median line.

Mesonotal praescutum light gray with three dark brownish black stripes; remainder of the mesonotum gray, each scutal lobe marked with dark brown, the scutellum and postnotum with a capillary brownish black median line. Pleura yellowish gray, indistinctly blotched with darker. Halteres light brown, the knobs with the basal half dark brown, the apical half yellowish. Legs with the coxæ grayish yellow; trochanters yellow; femora brownish yellow, the tips broadly black; tibiæ brown, the tips black; tarsi dark brown. Wings subhyaline, the costal and subcostal cells more yellowish; wings marmorate with dark and light brown; dark brown areas at the wing-base in cells R and M, at the origin of Rs, at the stigma and thence along the cord to cell *1st* M_2; the light brown areas include the broad wing-apex and extensive clouds in cells R, M, most of Cu_1, the ends of Cu, *1st* A and *2nd* A; the subhyaline areas appear as a broad, oblique crossband beyond the stigma, extending from cell *2nd* R_1 across the inner ends of cells R_2, R_3, R_5, through *1st* M_2 into the base of cell M_4; a large area near the bases of cells R and M; another beyond midlength of M; another before the stigma in cells *1st* R_1 and R; other subhyaline areas in cells Cu and *1st A;* cell *2nd A* largely subhyaline; veins dark brown. Venation: Cell R_2 large; vein R_2 beyond r longer than R_{2+3}; Rs long, about equal to R_3; petiole of cell M_1 shorter than m; m-cu punctiform or obliterated. In the female, the wings are considerably atrophied and the venation correspondingly distorted; the wings are dark brown, paler basally and along the costal region.

Abdominal tergites yellowish with three conspicuous dark brown stripes; segments six to nine more uniformly brownish; hypopygium indistinctly more reddish brown; sternites yellow, with a conspicuous median brown stripe. Male hypopygium relatively small. Eighth tergite reduced to a mere strip at the median line. Ninth tergite small,

not chitinized, with a broad, deep, U-shaped median notch. Ninth pleurite complete; outer pleural appendage narrow basally, expanded and darkened outwardly; inner pleural appendage large and very compressed. Ninth sternite not notched medially, the caudal margin being almost straight across, the median area provided with a small, cushion-like lobe. Eighth sternite unarmed. Ovipositor of the *arctica* type, the intermediate lateral teeth of the tergal valves moderately acute.

Habitat: Formosa. Holotype, ♂, Noko, May 11, 1919 (T. Shiraki) No. 1324. Allotopotype, ♀. Paratopotype, ♂.

Tipula bicornuta sp. n.

Antennæ of the male moderately elongated, indistinctly bicolorous; mesonotum gray, the praescutum with four indistinct greenish brown stripes; scutellum and postnotum with a capillary brown line; wings subhyaline with a rather pale grayish marmorate pattern; abdomen yellowish, dark brown apically; male hypopygium with the pleurites produced into cylindrical, black, curved horns.

Male—Length, 11 mm.; wing, 13 mm.; antenna about 5.2 mm.

Frontal prolongation of the head buffy; palpi brown. Antennæ of the male rather elongated, nearly half the length of the body; scape and first flagellar segment yellow, the remaining flagellar segments black basally, dark brown distally, to produce an indistinct bicolorous appearance; verticils very long, approximately as long as the segments that bear them. Head buffy with an indistinct capillary brown median line.

Mesonotal praescutum light gray, with four obscure greenish brown stripes, the intermediate pair contiguous anteriorly, soon bent outwards to leave a linear strip of the ground color between them; remainder of the mesonotum light gray, with a capillary brown median line, the scutal lobes with greenish brown centers. Pleura yellowish, sparsely white pruinose. Halteres light brown, the knobs dark brown, slightly paler at the tips. Legs with the coxæ pale, whitish pruinose; trochanters yellowish; femora brown, the tips broadly dark brown; tibiæ and tarsi dark brown. Wings subhyaline, the base and costal region yellowish; stigma brown; a weak gray clouding in the cells, including the wing-apex; clouds near midlength of cells R and M, and in the ends of cells *Cu, 1st A* and *2nd A;* the subhyaline areas include an oblique band beyond the stigma, passing from the outer end of cell *2nd* R_1 across the bases of cells R_2, R_3 and R_5, through *1st* M_2 into the base of cell M_4; veins dark brown. Venation: Cell R_2 large, vein R_2 being longer than R_{2+3}; Rs shorter than R_3; petiole of cell M_1 shorter than m; $m\text{-}cu$ obliterated by the fusion of Cu_1 on M_{3+4}.

Abdomen yellow basally, with an indistinct dorsal stripe; segments five to nine dark brown. Male hypopygium with the ninth tergite narrow, the caudal margin heavily chitinized and with a broad U-shaped

median notch and smaller lateral notches, separated by conspicuous blackened teeth. Ninth pleurite complete, the outer angle produced into a conspicuous, black, curved horn that is directed dorsad and slightly proximad. Ninth sternite with only a slight median notch, bearing a small lobe. Eighth sternite unarmed.

Habitat: Formosa. Holotype, ♂, Funkiko, April 21, 1917 (T. Shiraki), No. 1329.

Tipula formosicola sp. n.

Generally similar to *Tipula nova* Walker; head brown, paler adjoining the eyes; antennæ indistinctly bicolorous; wings dark brown, more grayish posteriorly, with a hyaline cross-band beyond the stigma, extending to beyond cell *1st* M_2; cell R_5 entirely clear; cell M hyaline with a large brown area near midlength and another at the outer end; abdomen rather long and slender; ovipositor with the valves slender, smooth.

Female—Length, 25 mm.; wing, 19 mm.; abdomen alone, 21 mm.

Frontal prolongation of the head and palpi dark brown. Antennæ with the first scapal segment grayish pruinose; second segment pale; flagellar segments yellowish, slightly darker basally, to produce a bicolorous effect. Head dark brown, paler on the vertical tubercle and adjoining the inner margin of the eyes.

Mesonotal praescutum buffy, with three dull brown stripes that are confluent, except behind near the suture; humeral region pale; a slightly darker, capillary median line that extends to the anterior margin of the praescutum; scutum buffy, each lobe with three brown spots; scutellum and postnotum grayish, the median area extensive, brown. Pleura grayish pruinose. Halteres comparatively long and slender, dark brown, the base of the stem abruptly and conspicuously yellowish. Legs with the coxæ light brown, light gray pruinose; trochanters yellowish, faintly gray pruinose; remainder of the legs broken. Wings dark brown, variegated with subhyaline, the anal cells light gray; the dark brown areas include the broad costal margin, extending caudad almost to M and reaching the still darker brown stigma which completely fills cell *2nd* R_1 and the outer half of *1st* R_1; wing-tip in the outer half of cells R_2 and R_3 dark brown; the subhyaline areas appear as a broad, transverse band beyond the stigma, occupying the basal half of cells R_2 and R_3, all of R_5, *1st* M_2 and the bases of M_1, *2nd* M_2 and M_4; these posterior cells are pale gray, only slightly darker than their subhyaline bases, but the color deepens in the anal cells of the wing; cell M is subhyaline with the apex and a cloud near midlength brownish; veins dark brown, those beyond the cord narrowly seamed with dark brown. Venation: Rs much longer than R_{2+3}; r shorter than R_2 beyond it; petiole of cell M_1 a little longer than *m; m-cu* distinct.

Abdominal tergites grayish, with a brown median stripe, the caudal margins of the segments paler. Abdomen comparatively long and slender. Ovipositor with the tergal valves slender, smooth; sternal valves compressed, slightly shorter than the tergal valves.

Habitat: Formosa. Holotype, ♀, Koshun, April 25–May 25, 1918 (J. Sonan, K. Miyake and M. Yoshino), No. 1323.

Tipula nova Walker.

1848. *Tipula nova* Walker; List Diptera British Museum, Part 1, p. 71.
1911. *Tipula fumifasciata* Brunetti; Rec. Indian Museum, vol. 6, p. 250.
1916. *Yamatotipula nohiræ* Matsumura; Thousand Ins. Japan, Addit. 2, p. 461.

One male, Taito, Formosa, February 25–March 27, 1919 (S. Inamura, J. Sonan, and M. Yoshino), No. 1323. The synonomy of *T. nohiræ* with *T. nova* is due to a communication from Mr. Edwards.

Tipula pluriguttata sp. n.

Antennal scape yellow; head and thorax gray with a capillary brown median line extending from the vertical tubercle to the base of the abdomen; wings yellowish gray, the base and the costal region more yellowish; cell R_2 small; abdomen yellow, the tergites with three dark brown stripes, the sternum with a conspicuous median stripe.

Female—Length, 16–17 mm.; wing, 15.5–17 mm.

Frontal prolongation of the head dark brown, more yellowish laterally; palpi dark brown. Antennæ with the basal four or five segments yellowish, the remaining segments indistinctly bicolorous; in some specimens, only the scape is yellow, the flagellar segments being almost uniformly dark. Head dull gray with a capillary brown line.

Mesonotal praescutum dull gray, more buffy laterally, the three usual stripes darker gray, the interspaces but little paler; median praescutal stripe split by a capillary brown line that broadens out at the scutum, extending thence to the abdomen; praescutal interspaces with numerous dark brown dots surrounding setigerous punctures; scutum gray, the median area brown, the lobes bilineate with brown; scutellum with the median area buffy, dark brown medially; postnotum obscure gray, the median line brown. Pleura buffy, sparsely pruinose. Halteres brownish yellow. Legs with the coxæ and trochanters buffy yellow; femora obscure yellow, with a comparatively narrow dark brown ring before the narrow tips; tibiæ obscure yellow, the tips narrowly dark brown; tarsi dark brown. Wings faintly yellowish gray, the wing-base strongly yellow, cells *C* and *Sc* yellow; stigma elongate, brown; a narrow brownish seam along *Cu;* veins dark brown. Venation: *Rs* long, straight, lying close to *R;* R_{2+3} in alignment with R_3; cell R_2 very small, the apex of vein R_2 pale, subatrophied, without macrotrichiæ; *r* very long, much longer than R_2 beyond it, provided with about thirteen

macrotrichiæ; cell *1st* M_2 pentagonal; cell M_1 deep, its petiole about as long as cell *1st* M_2 and between two and three times as long as *m; m-cu* very short.

Abdomen yellowish, the tergites with three longitudinal stripes, the median stripe broad and very conspicuous; sternites with a conspicuous dark brown median line. Ovipositor with the tergal valves slender, almost straight; sternal valves much shorter, compressed.

Habitat: Formosa. Holotype, ♀, Funkiko, April 25, 1917 (T. Shiraki), No. 1326. Paratopotypes, 5 ♀'s, April 21–25, 1917.

THE MYRIOPOD FAUNA OF THE BERMUDA ISLANDS, WITH NOTES ON VARIATION IN SCUTIGERA.

RALPH V. CHAMBERLIN.

The present paper is based upon a study of several lots of chilopods and diplopods from the Bermudas, belonging chiefly to the Museum of Comparative Zoology, at Cambridge, Mass., and to the United States National Museum, at Washington, D. C. The collections embrace material secured by Prof. J. H. Comstock, in 1903, the Yale Expedition to the Bermudas in 1898, Prof. A. E. Verrill in 1901, Mr. Owen Bryant and Dr. Thomas Barbour in 1903, Dr. R. W. Glaser, Dr. G. B. Goode, and material from the Bermuda Biological Station for Research collected by Prof. E. L. Mark in 1903, and Dr. W. L. Crozier in 1917 and 1918. An examination of this material has brought to light all species previously recorded and six species not previously known to occur upon the islands, bringing the total of chilopods and diplopods together to fifteen species. These forms are as follows:

DIPLOPODA.

Julus moreleti Lucas.
Julus bermudanus, sp. nov.
Julus nesophilus, sp. nov.
Rhinocricus monilicornis (Porath).
Rhinocricus ectus, sp. nov.
Microspirobolus excursans, sp. nov.
Orthomorpha coarctata (Saussure).
Strongylosoma guerinii (Gervais).

CHILOPODA.

Scolopendra subspinipes Leach.
Mecistocephalus maxillaris Gervais.
Hydroschendyla submarina (Grube).
Lamyctinus cæculus (Brolemann).
Lithobius provocator (Pocock).
Tidabius navigans (Chamberlin).
Scutigera coleoptrata (Linné).

Of these species three of the chilopods and one of the diplopods occur in the warmer parts of the entire world, these tropicopolitan forms being *Orthomorpha coarctata*, *Scolopendra subspinipes*, *Mecistocephalus maxillaris*, and *Lamyctinus caeculus*. Of the remaining species it is rather surprising to find that only one, namely *Rhinocricus monilicornis*, occurs also in the West Indies, though it is quite possible that the other Rhinocricus and the Microspirobolus may with further exploration be found there, the present evidence being, however, that they are indigenous. In fact, four out of the six genera represented by the remaining species—Lithobius, Tidabius, Hydroschendyla

and Julus—do not occur in the West Indies, and the presence of Scutigera in the restricted sense is doubtful. The other genus, Strongylosoma, is tropicopolitan.

Of the species found upon the Bermudas, four occur also in southwestern Europe, inclusive of the Azores, these being *Julus moreleti, Strongylosoma guerinii, Hydroschendyla submarina* and *Scutigera coleoptrata.* The Scutigera appears also to be the same species as the common North American form. In addition, there is in North America a widespread species, *Tidabius tivius* Chamb., which is exceedingly close to and perhaps only varietally distinct from the Bermudan *Tidabius navigans.* Omitting this form, there remain five species apparently indigenous, two of which have West Indian affinities and the others of which must have had European or North American ancestry, but most probably the former. Omitting the four tropicopolitan species, eight of the eleven remaining species are in their affinities European and North American, the other three West Indian.

Diplopoda.

JULIDÆ.

Julus moreleti Lucas.

In Arthur Morelet's Iles Açores, Paris, 1860, p. 96.

Julus moreleti Porath, Öfvers, af Vet. Akad. Förh., 1870, 27, p. 820, pl. 10, figs. 9, 10.
Julus moreleti Bollman, Proc. Acad. Sci. Phil., 1889, p. 128.
Julus moreleti Pocock, Ann. and Mag. Nat. Hist., 1893, ser. 6, 11, p. 123.
Julus moreleti Chamberlin, Proc. Acad. Sci. Phil., 1904, p. 653.

This species was originally described from the Azores. It is also found in the Madeira Islands. It is abundant on the Bermudas.

Localities: Bermuda (O. Bryant, 1903; J. H. Comstock, 1893; Wm. W. Barbour, A. E. Verrill, 1901; Yale Exped.,1898); Flatts Inlet (O. Bryant, 25 June, 1903); Harrington Sound, (Bermuda Biol. Sta., R. W. Glaser); Paynter's Vale (Bermuda Biol. Sta., E. L. Mark, April, 1903); Tucker's Id. (A. E. Verrill, 3 May, 1901); Point Shares (Bermuda Biological Station for Research, W. L. Crozier coll., 5 Oct., 1917).

Julus bermudanus sp. nov. (Figs. 1 and 2).

Light brown, with a tendency toward light chestnut. Lacking a middorsal dark line and also dark lines along the sides in the types, or some of the repugnatorial glands showing weakly as darker spots. On each somite a darker transverse band across dorsum in front of suture, on dorsum in front of suture an included narrower band of lighter spots separated by a network of dark lines; a similar areolation below each repugnatorial pore. Collum with a dark band across anterior border, this narrowing down each side; plate elsewhere with network of fine dark lines over paler ground. Anal tergite and valves dusky. A darker band over and between eyes.

Vertex of head lacking setigerous foveolæ; crossed by a fine but distinct sulcus. Each eye consisting of twenty to twenty-two ocelli in five series: e. g., 6, 5, 4, 3, 2 and 6, 5, 5, 3, 2. Antennæ in length about equalling the width of the body.

Collum angularly narrowed down each side, narrowly rounded below; just above each lateral end with two or three striæ.

FIG. 1

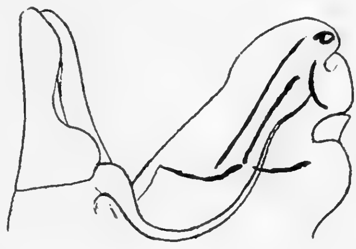


FIG. 2

Fig. 1. Anterior gonopods of *Julus bermudanus* sp. nov., cephalic aspect.
Fig. 2. Mesal aspect of left gonopods of *Julus bermudanus*, sp. nov.

Second and next few segments with striæ back of suture below level of pores, none on dorsum. Farther caudad, however, the striæ are distinct entirely across dorsum. Striæ deeply impressed and extending to or nearly to the caudal edge, the smooth border at most very narrow. Prozonites smooth and shining. Suture distinct, straight, not curved or angulate at level of pore. Pores in contact with sutures on caudal side of which they lie.

Anal tergite rounded behind, equalling or slightly exceeded by the valves. Anal valves mesally slightly margined, a distinct sulcus setting off a narrow but only weakly elevated mesal rim on each.

In the male the cardo of mandibles produced in a laminate form ventrad or caudoventrad, the edge entire. First legs chitinous, strongly uncate. Gonopods concealed. Gonopods having the general arrangement of those of *luscus;* but anterior pair larger, with distal edge less oblique and the posterior pair more conspicuously different and the relations of flagellum also different. (See Figs 1 and 2).

Number of segments (♂), 40–41. The last three or four segments apodous.

Length, near 12 mm.; width, 1.1–1.2 mm.

Locality: Bermuda (J. H. Comstock, 1903, one male, type, author's coll., A. E. Verrill, 1901, one male, paratype, U. S. N. M.)

This species falls in a group with the European *J. luscus* Meinert, *J. londinensis* Leach, *J. britannicus* Verhoeff, etc.

Julus nesophilus sp. nov.

Body in general fuscous, annulate with pale. Collum with a dark band behind a pale anterior border, elsewhere areolate with light. Head with a dark band across and between eyes, the vertex with numerous small light dots in a darker network. Body glabrous.

Head with no setigerous foveolæ on vertex. The usual four foveolæ on clypeus. Antennæ slender and rather shorter than the width of the body. Eyes black, transversely and rather narrowly elliptic. Ocelli about forty-eight in near ten oblique series, e. g., 2, 4, 5, 6, 6, 6, 7, 6, 4, 2.

Collum exceeded by the second segment, at sides rather widely rounded; marked below on each side with three distinct striæ of which the second continues along anterior border as the margining sulcus; above these the caudal border is crossed by a number of shorter striæ, the series extending entirely across plate.

Second segment on each side a little extended forward beneath the collum; strongly striate beneath and part way up the sides, weaker striæ also existing entirely across dorsum. On third and fourth segments the striæ are a little deeper and on subsequent ones strongly marked entirely about the metazonites, the prozonites remaining smooth. The striæ extend to or nearly to the caudal edge, the smooth border, where at all evident, being very narrow. Each repugnatorial pore on the anterior and median segments lies immediately in front of the general level of the segmental suture, but the latter curves forward about it, embracing it closely, excepting on the caudal side. In the more caudal segments the pore is relatively farther caudad and the suture curves more and more gently, becoming more open and not embracing the pore.

Anal tergite not at all caudate or produced, posteriorly obtusely subangulate; a little exceeded by the valves. Mesal borders of anal valves moderately protruding, but not distinctly margined. Anal scale subtriangular, narrowly rounded behind, smooth.

Number of segments (♀), forty-two.

Length, 23 mm.; width, 2.4 mm.

Locality: Harrington Sound. One female (R. W. Glaser). M. C. Z.

I have been unable to identify this with any European or North American species. In the absence of knowledge of the male, however, nothing can be safely asserted as to its more immediate affinities.

RHINOCRICIDÆ.

Rhinocricus monilicornis (Porath).

Spirobolus monilicornis Porath, Bih. Svensk. vet.-Akad. Handl., 1876, 4, no. 7, p. 31.
Spirobolus heilprini Bollman, Proc. Acad. Sci., Phil., 1889, p. 127.
Spirobolus monilicornis Pocock, Ann. Mag. Nat. Hist., 1893, ser. 6, 11, p. 123.

This species appears to be well distributed in South America and the West Indies and is obviously common on the Bermudas.

Localities: Bermuda (Yale Exped., 1898); Hanging Bay (O. Bryant, 27 June, 1903); Harrington Sound (R. W. Glaser); Hungry Bay (A. E. Verrill, April, 1901).

Rhinocricus ectus sp. nov.

Black, each segment with a yellow or ferruginous annulus embracing the caudal half of metazonite or but little more, though often widening down the sides. Collum black, excepting a narrow, pale caudal border on the former, Legs brick red.

Sulcus across vertex distinct, widely interrupted in the frontal region where the head is depressed, the median sulcus evident again across lower part of clypeus. Antennæ short; sensory cones numerous.

Collum rounded below. Margined along anteroventral corner, otherwise smooth and non-striate, or with but a single weak stria just above caudal portion of margining one; exceeded by the second tergite, which extends forward beneath it and bends down a little at anterior edge; flattened beneath where alone it is striate.

Segmental sulcus sharply impressed and distinct throughout. In front of it always a second sulcus which is distinct entirely across dorsum and ordinarily takes its origin a little above level of pore, where it bends rectangularly back toward primary sulcus. Below it is a stria which extends obliquely caudoventrad below pore, a series of other similar fine oblique stries following below it. Pore just in front of the primary sulcus which is gently curved opposite it. Metazonites strongly striate below middle of sides, the series ending some distance below level of pores. Scobina extending back to or near the thirty-fifth somite.

Anal tergite angulate behind, the angle caudally rounded; not caudate, exceeded by the valves. Valves mesally protruding, but not margined or so sharply elevated as in *monilicornis*.

Number of segments, forty-four or forty-five.

Length, 35 mm.–40 mm.; width, 3.5 mm.–4 mm.

Locality: Bermuda (M. C. Z. coll.)

The types of this species are two females. It appears to be close to *R. consociatus* Pocock of Union Id., W. I.; but lack of males of the present form and of specimens of *consociatus* for comparison makes definite conclusions as to precise relationship

impracticable. The Bermudan form is more robust, having a width of 4 mm. as against 3 mm., the legs are brick-red instead of lurid, and the pale border of the anal tergite is narrower. More important, the anal tergite of *consociatus* is said, in Pocock's key (Jour. Linn. Soc., 1893, 24, p. 487, etc.) to be produced, though scarcely exceeding the valves. It is not caudate in the present form.

SPIROBOLELLIDÆ.

Microspirobolus excursans sp. nov.

Body in general of a light brown color with dorsum showing a tendency toward a weakly reddish tinge. Typically a darker brown band along each side at level of pores embracing a series of black spots formed by the repugnatorial glands which are always conspicuous. A rather faint middorsal dark line. Each ordinary segment crossed above by a pale band at or in front of the constriction, this bending back at middle where divided by middorsal dark line, sometimes embracing most of prozonite. Legs pale brown or fulvous. Collum without dark markings. Anal segment also light, or sometimes more or less dusky.

Head smooth. A fine sulcus across vertex, ending in a small impressed foveola at upper level of eyes. Clypeal setigerous foveolæ 4+4, the two outermost on each side more widely removed. Eyes subtriangular with apex toward base of antenna and the sides rounded. Ocelli distinct, about thirty-one in number, arranged typically in five rather irregular, subvertical series, e. g., 5, 6, 7, 9, 4. Antennæ very short, gradually enlarged to sixth joint, fitting in a groove in head and mandible on each side.

Collum projecting forward over base of head. Widely rounded below, the anterior corner subrectangularly rounded, the posterior more oblique, the lower edge somewhat flattened or even slightly indented. Margined below and up front as far as level of eyes, otherwise nonstriate and smooth.

The following segments each have the metazonite obviously considerably elevated above level of prozonite, the segment more or less constricted or furrowed about middle, especially laterally. Pore well removed back of furrow, lying half way to the caudal edge from the furrow. Deeply longitudinally striate beneath; laterally with curved striæ on prozonite in and just back of furrow up to level of pore and fewer more straight striæ in corresponding place on metazonite. Dorsally the prozonite is characteristically marked with a network of impressed lines, outlining hexagonal areas, the areas decreasing in size forward from furrow. Metazonite wholly smooth dorsally.

Anal tergite rounded behind, not at all projecting beyond valves. Anal scale transversely narrowly elongate, the caudal edge nearly straight.

Number of segments, thirty-five to forty, mostly thirty-seven or thirty-eight.

Length, near 18 mm.; width, to 2 mm. Male more slender than female.

Locality: Bermuda. Point Shares. Several specimens taken under rotten wood (Bermuda Biol. Sta. for Research, W. L. Crozier coll., 5 Oct., 1917). In M. C. Z. coll.

No adult male is represented, so the reference to Microspirobolus is in some degree tentative. It seems to conform so far as may be judged from females, which much resemble those of West Indian species.

STRONGYLOSOMIDÆ.

Strongylosoma guerinii (Gervais).

Polydesmus Guerinii, Ann. Soc. Ent. France, 1836, p. 686.
Strongylosoma Guerinii Gervais, Ons. Apt., 1847, 4, p. 116.
Strongylosoma Guerinii Pocock, Ann. and Mag. Nat. Hist., 1893, ser. 6, 11, p. 116.

In the collection of the U. S. Nat. Mus. is a female of this species taken on Bermuda by G. B. Goode. It was also in material collected on the islands by the Challenger Exped. (Pocock, Op. cit.). This species is common on the eastern side of the Atlantic in the Azores, Madeira, Spain, Portugal, Teneriffe, Algeria, Tunis, and Kameroon.

Orthomorpha coarctata (Saussure).

Polydesmus coarctatus Saussure, Mem. Soc. phys. Geneve, 1860, p. 39, fig. 18.
Strongylosoma coarctatum Pocock, Ann. and Mag. Nat. Hist., 1893, ser. 6, p. 123.

This species now has a tropicopolitan distribution and is one of the millipedes most frequently met with on tropical islands everywhere. Pocock records it from Bermuda (Op. cit.), and I have examined two specimens from the Bermuda Biological Station for Research, collected by W. L. Crozier at Point Shares, 5 Oct., 1917, where they were found under rotten wood.

CHILOPODA.

SCOLOPENDRIDÆ.

Scolopendra subspinipes Leach.

Trans. Linn. Soc., London, 1814, 11, p. 383.
Scolopendra subspinipes Pocock, Ann. and Mag. Nat. Hist., 1893, ser. 6, 11, p. 123.

This large centipede is found commonly throughout the warmer parts of the earth, excepting the Mediterreanean region. Its centre of distribution, however, would seem undoubtedly to be the East Indian region, where it is most abundant and presents its greatest variations.

Localities: Bermuda Id. (south side of Id., O. Bryant, 21 Aug., 1903; E. L. Mark, April, 1890; U. S. N. M. Coll.; no other data). Tucker's Id. (E. L. Mark, 1 Aug., 1907).

MECISTOCEPHALIDÆ.

Mecistocephalus maxillaris (Gervais).

Geophilus maxillaris Gervais, Ann. Sci. Nat., ser. 2, 1837, 7, p. 52.
Mecistocephalus guildingii Newport, Trans. Linn. Soc. London, 1845, 19. p. 429.
Mecostocephalus guildingii Bollman, Proc. Acad. Sci. Phil. 1889, p. 129.

A tropicopolitan species, though commonly occurring rather sparsely. It is well known, e. g., from South America, West Indies, Hawaii, Samoa, Philippines, New Guinea, India and Africa. It also sometimes occurs in hothouses in temperate regions, as in Europe and North America (Washington, D. C.)

Localities: Bermuda Id. (South side, O. Bryant, 21 Aug., 1903); Harrington Sd. (R. W. Glaser); Dyer Id. (15 June, 1918, W. L. Crozier); Waterloo (A. E. Verrill, April., 1901).

SCHENDYLIDÆ.

Hydroschendyla submarina (Grube).

(Pl. XXII, Figs. 1 to 5)

Geophilus (Schendyla) submarinus Grube, Abh. Schles. Ges. vaterl. Cultur, Breslau, 1869, p. 82.
Hydroschendyla submarina Brölemann and Ribaut, Nouv. Archiv du Mus. d'Hist. Nat., ser. 5, 4, p. 137, pl. 7, figs. 110-118.

It is a matter of considerable interest to be able to add to the known chilopod fauna of the Bermudas this European marine geophiloid. The form was previously known to occur on the Mediterreanean and Atlantic coasts of France, the coasts of England (Jersey, Plymouth) and Ireland (Galway), and northward to Denmark and Sweden. It has also been recorded from Italy (Portici, Berlese, 1882); but there is some doubt as to the correctness of the identification in this case. Grube (Op. cit., p. 82–83) found it at St. Malo and Roscoff often in large numbers under stones and in fissures covered at high tide. A male of this species was taken by O. Bryant on the Bermudas at Hungry Bay (10 July, 1903), where it was "found under a stone nearly at low tide mark." I have examined also a female taken at Port Royal (25 June, 1918) in a similar location by Dr. W. L. Crozier, who has supplied me with the following field notes on the form." The intertidal form lives (a) around the

edges of eroded, flat stones; (b) in isolated and much honeycombed blocks of limestone; in either case about nine inches below mean high water. The rock, porous aeolian limestone, or beach rock, is much eroded. The situation is usually muddy (i. e., deposits of silt, calcareous, on the rock). The centipede comes very near to the surface of the rock, sticks its head out into the open, and is even seen running over the moist surface of shaded stones. The animals are not plentiful, but I have seen them at Flatts Inlet, at Port Royal, Great Sound, and at Dyer Id. The rocks inhabited by them are frequently found in little coves, moderately shaded by overhanging ledges. *Onchidium floridanum* lives in the same situations and sometimes uses the same cavities. The centipede eats leodicids, in five instances I have noted, by biting into the side of the creature, licking up the juices and creeping off out of sight with one of the fragments into which the worm autotomises. The centipede, except for color, looks not very unlike the leodicids, which occur plentifully in similar situations, though the distribution of the two types is not coincident. As I remember, Dr. Treadwell found none of the centipedes in all his rock-splitting operations after worms, although he was more or less on the lookout for them. It creeps much like an annelid, the body thrown into waves."

It may be mentioned that the closely allied *Pectiniunguis americanus* also seems to have a strictly littoral habitat, occurring under sea-weed, drift-wood, etc., on the coasts of the Gulf of Mexico, including Florida, and on the coasts of Lower California. Another geophiloid of a different family, *Linotaenia maritima* (Leach), seems similarly to have a littoral habitat. Its distribution in Europe is nearly the same as that of *Hydroschendyla submarina* Its habits are indicated in the following note by R. I. Pocock.* "Great, therefore, was my astonishment, when, turning over the line of seaweed marking the high spring-tide, to find specimens of all sizes swarming amongst the slimy decaying fronds and wriggling away into darkness in company with hosts of scuttling woodlice and hopping sand-shrimps; while here and there was a cluster of them feeding upon the remains of one of the crustaceans." It is significant to note that the geophiloids in general seem to have a strikingly

* Marine Centipede in Somerset, Zoologist, 1900, ser. 4, 4, p. 484.

greater power of resistance to prolonged submersion in fresh as well as in sea-water than other chilopods, such as scolopendrids, as has been experimentally demonstrated by Plateau.*

After examining only the male of this form from the Bermudas, I was inclined to consider it as distinct from the European species; but further study of a female in comparison with one from Banyuls-sur-Mer, France, kindly sent to me by Dr. Brölemann, shows the Bermudan and European forms to be undoubtedly identical. The male and female from the Bermudas have respectively forty-seven and forty-nine pairs of legs, the numbers most frequent in European specimens, and measure 32 and 20 mm. in length. They are yellow, excepting the end regions which are ferruginous. Structurally they agree in general with the exhaustive description given by Brölemann and Ribaut (Opp. cit.). In this description no mention is made of definite chitinous pockets in a few of the anterior plates; but the specimens agree in showing these. The Bermudan male, cleared and mounted, shows pronounced and strongly chitinized infoldings, or pockets, in the anterior edges of the ninth to thirteenth sternites, with a much shallower one on the eighth and fourteenth. The prebasal plate in the male is covered; but this is probably due to shrinkage in the alcohol, as it is exposed in the normal manner in the female.

LITHOBIIDÆ.

Lithobius provocator Pocock.

Ann. and Mag. Nat. Hist., 1891, ser. 6, 8, p. 152.

Lithobius provocator Pocock, ibid., 1893, 11, p. 122.
Lithobius bermudensis Pocock, ibid., 1893, 11, p. 126.
Lithobius provocator Chamberlin, Proc. Acad. Sci. Phil., 1904, p. 653.

Color varying from light to deep brown, often showing a median longitudinal pale stripe, and the head with first and last one or two plates commonly more reddish, chestnut to mahogany. Prosternum and prehensors brown, the latter rufous distally. Antennæ brown to mahogany, mostly nearly uniform. Posterior legs concolorous with dorsum, uniform or with last one or two articles paler.

Head subcordate, widest at or a little in front of marginal breaks. A little wider than long (25 x 24). Hairs short and few. Punctæ weak and scattered. Antennæ with articles thirty-seven to fifty-eight in number, forty-six being frequent; reaching seventh or eighth segment.

* Les Myriopodes marins et la Resistance des Arthropodes a respiration aerieen a la submersion, Jour. de l'Anat. et Physiol, 1890, 26, p. 236-269.

Ocelli fourteen to twenty-five, in four or five series: e. g., 1+4, 4, 3, 2; 1+5, 5, 4, 3; 1+5, 5, 4, 4, 3; 1+6, 5, 5, 5, 3. Single ocellus suboval, much largest, well separated from the others. Ocelli of most dorsal row largest, the others decreasing gradually and usually uniformly ventrad. Organ of Tomosvary on ventral surface ventrocephalad of eye-patch, in size about equalling one of the smaller ocelli.

Prosternum 1.73± times wider than long. Distance between chitinous spots not quite twice the width at level of mesal incision or interval; 2.23± times the dental line. Teeth 4+4 to 8+8, mostly 5+5 or 6+6 and frequently 5+6, a small extra tooth appearing in the diastema which normally separates the outermost tooth on each side from the others, or sometimes two, 6+8, the odd tooth or teeth most often noted on the right side. Teeth distally rounded, each commonly appearing to be separately a little elevated. Alternate teeth often reduced. Ectal spine long and acute, truly spiniform, situated just back of the diastema on each side. When the larger numbers of teeth are present, one or more commonly appear in the diastema, thus apparently obliterating it, but the spine always retains the normal position.

Posterior dorsal plates under a lens commonly appearing tuberculate or rugose, the anterior ones smoother. Posterior angles of ninth, eleventh and thirteenth plates strongly produced. Widths of head and of first, third, eighth, tenth and twelfth plates to each other nearly as 35 : 35 : 34 : 35 : 35 : 35, the sides being nearly parallel over much of length. A specimen 24 mm. long has the tenth plate 3.5 mm. wide, the body thus only 6.8 times longer than wide in this case.

Coxal pores transversely elongate, from elliptic to oblong or key-hole shaped: 5, 7, 7, 5 to 7, 9, 9, 7, other arrangements noted being 6, 8, 8, 6 and 7, 8, 8, 7. Sometimes two small pores appear side by side in the most proximal position.

Spines of first legs, $\frac{0,\ 0,\ 3,\ 2,\ 1}{0,\ 0,\ 2,\ 3,\ 2}$; of second to tenth, inclusive, $\frac{0,\ 0,\ 3,\ 2,\ 2}{0,\ 0,\ 2,\ 3,\ 2}$; of the elevanth and twelfth, $\frac{0,\ 0,\ 3,\ 2,\ 2}{0,\ 0,\ 3,\ 3,\ 2}$; of the thirteenth $\frac{1,\ 0,\ 3,\ 2,\ 2}{0,\ 1,\ 3,\ 3,\ 2}$; of the fourteenth, $\frac{1,\ 0,\ 3,\ 1,\ 1}{0,\ 1,\ 3,\ 3,\ 2}$, claws 2, or a third one scarcely evident; of anal, $\frac{1,\ 0,\ 3,\ 1,\ 0}{0,\ 1,\ 3,\ 3,\ 1}$, claws 2. Last three pairs of coxæ laterally armed.

Claws of female gonopods rather short, tripartite, the lobes short. Basal spines 2+2, rather long, of about equal width from base to beginning of the short, acuminate tip which occupies only about one-fourth of total length, the sides parallel or a little incurved.

Length, 18 to 27 mm.

Praematurus—Antennæ consisting of forty-one articles. Each eye consisting of ten ocelli, thus, 1+4, 3, 2.

Prosternum with teeth 4+4 of which the outermost and innermost on each side are smaller than the others. The most mesal tooth on each side is, as usual, closer to the next tooth than the others are to each other, the intervals between the first and second and the second and third from the outside being large. Spine in normal position opposite interval between first and second teeth.

Coxal pores 5, 5, 5, 5, circular and subcircular.

Spines of first legs $\frac{0,\ 0,\ 2,\ 2,\ 1}{0,\ 0,\ 1,\ 2,\ 1}$; of the second $\frac{0,\ 0,\ 3,\ 2,\ 1}{0,\ 0,\ 2,\ 3,\ 2}$; of the third to seventh, $\frac{0,\ 0,\ 3,\ 2,\ 2}{0,\ 0,\ 2,\ 3,\ 2}$; of the eleventh, $\frac{0,\ 0,\ 3,\ 2,\ 2}{0,\ 0,\ 2,\ 3,\ 2}$; of the twelfth $\frac{1,\ 0,\ 3,\ 2,\ 2}{0,\ 0,\ 3,\ 3,\ 2}$; of the thirteenth, $\frac{1,\ 0,\ 3,\ 1,\ 2}{0,\ 1,\ 3,\ 3,\ 2}$; of the fourteenth, $\frac{1,0,3,1,1}{0,1,3,3,3}$; and of the anal, $\frac{1,\ 0,\ 3,\ 1,\ 0}{0,\ 1,\ 3,\ 3,\ 1}$. Last three coxæ laterally armed.

Claw of gonopods of female tripartite, the lobes acute, the median one much longest. Spines 2+2, acute, tapering from base, the inner one of each pair about two-thirds the length of the outer one.

Length, 12 to 14 mm.

Agenitalis II—Antennæ consisting of thirty articles of which the ultimate is long, equalling the three preceding ones taken together. Each eye composed of five ocelli arranged in two series: thus, 1+2, 2, the single ocellus oboval, but slightly largest, all well separated.

Prosternum with teeth 2+2, subacute, those of each pair well separated. Median interval semicircular. Spine near ectal corner on each side, straight.

Coxal pores circular 1 (2), 2, 2, 2.

Spines of first legs, $\frac{0,\ 0,\ 0,\ 1,\ 1}{0,\ 0,\ 0,\ 1,\ 1}$; of the second and third, $\frac{0,\ 0,\ 1,\ 1,\ 1}{0,\ 0,\ 0,\ 1,\ 1}$: of the fourth, $\frac{0,\ 0,\ 1,\ 1,\ 1}{0,\ 0(1),\ 1,\ 1}$; of the fifth, $\frac{0,\ 0,\ 1,\ 1,\ 1}{0,\ 0,\ 1,\ 1,\ 1}$; of the sixth, $\frac{0,\ 0,\ 1,\ 1,\ 1}{0,\ 0,\ 1,\ 2,\ 1}$; of the seventh, $\frac{0,\ 0,\ 2,\ 2,\ 1}{0,\ 0,\ 1,\ 2,\ 1}$; of the eighth and ninth, $\frac{0,\ 0,\ 2,\ 2,\ 2}{0,\ 0,\ 1,\ 2,\ 1}$; of the tenth, and eleventh, $\frac{0,\ 0,\ 3,\ 2,\ 2}{0,\ 0,\ 1,\ 2,\ 1}$ of the twelfth, $\frac{0,\ 0,\ 3,\ 1,\ 1}{0,0,2,2,2(1)}$; of the thirteenth, $\frac{1,\ 0,\ 3(1),\ 1,\ 1}{0,\ 0,\ 2,\ 2,\ 1(2)}$; of the fourteenth, $\frac{1,\ 0,\ 3,\ 1,\ 1}{0,\ 1,\ 3,\ 3,\ 1}$, claws two; of the anal, $\frac{1,\ 0,\ 3,\ 0(1),\ 0}{0,\ 1,\ 3,\ 2,\ 0}$, claws two. The lateral spine of the anal coxæ is represented by a minute transparent point not at all developed on the others.

Length, cir. 7.6 mm.

Localities: Bermuda Id. (Yale Exped., 1898, A. E. Verrill, 1901, O. Bryant, J. H. Comstock); Flatts Inlet; Hamilton (T. Barbour, 1903); Tucker Id. (A. E. Verrill, 1901); Paynter's Vale (Bermuda Biol. Sta. for Research, E. L. Mark, 1903); Hungry Bay (O. Bryant); Harrington Sd. (Bermuda Biol. Sta. for Research, R. W. Glaser).

Evidently a very common species on the islands. Pocock's *Lithobius bermudensis* agrees so nearly with the praematurus stage of *provocator* that I regard them as the same. While in specimens of the length designated by Pocock the prosternal teeth are ordinarily 3+3 or 4+4, I have two individuals of the praematurus stage 12 mm. long in which the prosternal teeth are 2+2 and 2+3 respectively.

While in general appearance this species much resembles the common European and North American *Lithobius forficatus* Linné, Pocock's suggestion (1893, Loc. cit.) that it may not be a truly distinct form is not well founded. Aside from the presence of two claws on each anal leg and the lateral arming of the last three pairs of coxæ, an even more important difference is evident in the prosternum, where the position of the special spine mesad of the ectal tooth on each side distinguishes the Bermuda form not only from *forficatus*, but apparently also from other species of the genus in its more restricted sense. Correlated with this position of the spine is the normal presence of a diastema separating the outer tooth from the others, though this may often show one or more interpolated minor teeth.

SCUTIGERIDÆ.

Scutigera coleoptrata (Linne).

Scolopendra coleoptrata Syst. Nat., ed. 10, 1, 1758, p. 637.
Scutigera coleoptrata Pocock, Ann. and Mag. Nat. Hist., 1893, ser. 6, 11, p. 122, 124.
Scutigera forceps Verrill, Trans. Conn. Acad. Sci., 1902, 11, p. 843.

This house-centipede seems not to be uncommon on the main island where it occurs in houses and cellars, etc. Verrill also took a specimen at the old forts on Castle Id. Five specimens which I have had for examination, seem not to differ from *Scutigera coleoptrata* (Linné), a species occurring commonly also in the Azores, Madeiras and the western and more southern parts of Europe. On the other hand, the species seems to be also identical with the common North American form. At any rate it seems impossible to separate alcoholic material

from the three regions mentioned on the basis of any characters thus far pointed out. I cannot speak with confidence as to coloration as it may be present in the living animals. Certainly there can be no separation on the basis of the characters to which Verhoeff gives primary importance in his study of the genus in Europe,* such as the number and arrangement of the spinules on the fifth, sixth and seventh tergites, the number of articles in the first division of the antennæ (*flagellum primum*), the number of divisions in first and second tarsi and the number and arrangement of the "pegs" on the latter, and the number and arrangement of spinules on the several joints of the legs. In fact, the variation in these characters in such, often on the two sides of the same animal, that one cannot help feeling skeptical as to the validity of the species and subspecies established by Verhoeff in the place mentioned, since the characters are used in the key with rather narrow limits, and the material studied by him was not extensive.

The tabulations which follow are constructed to represent the variations found in the characters mentioned in several individuals from the Bermudas and from the United States in comparison with a standard one from Toulouse, France, sent me through the kindness of Dr. Brölemann. In the first table the plus sign in the first two columns in the case of each tergite is used to separate the number on the left side from that on the right. In the third column is given only the general total of spinules for the surface, exclusive of margins and saddle. In the second table, showing the number of articles in the first division of the antennæ and in the first and second tarsi, the plus sign is used to separate the number of articles in the first tarsus (always given first) from the number in the second. In the subsequent tabulations, giving the spinules of the legs, the plus sign where appearing under femur and tibia is used to separate the number of spines at the distal margin given after the sign, from the number appearing proximad of this in the position indicated. Under tarsus I the sign separates the number of spinules appearing on successive articles beginning with the first. Under tarsus II the numbers given represent the number of segments, counting from the most proximal, upon which pegs appear. Where in this column a dash appears, it

* Über Scutigeriden, 5, Aufsatz, Zool. Auz., 1905, 19, p. 76.

indicates that pegs appear continuously on joints between those thus separated, inclusive; e. g., 11–13 means that a peg appears on each of the eleventh, twelfth and thirteenth articles. In ascertaining the spinules of the legs the method was in general to clear and mount the legs in order, with anterior faces down. It was thought sufficient for the present purposes to count the spinules of dorsal and ventral lines, in the case of femur and tibia, and of those that appear on the intermediate caudal surface in the three lines of hair approximately caudodorsal, caudomesal and caudoventral in position, since the spinules of the anterior surface vary in similar degree. Thus the abbreviations at the heads of the minor columns stand respectively for dorsal, ventral, caudodorsal, caudomesal and caudoventral.

The lengths of the several individuals furnishing the data given in the several tables are as follows:

Bermuda a, 23 mm.	Boston a, 23 mm.
Bermuda b, 19 mm.	Boston b, 20 mm.
Bermuda c, 21 mm.	Boston c, 19 mm.
Bermuda d, 22 mm.	Boston d, 22 mm.
Bermuda e, 16 mm.	Beaufort, N. C., 20 mm.
France, 25 mm.	Texas, 25 mm.
Salem, Mass., 26 mm.	Washington, D. C., 17 mm.

TABLE I.

SPINULES OF DORSAL PLATES.

	PLATE V			PLATE VI			PLATE VII		
	Margin	Saddle	Other	Margin	Saddle	Other	Margin	Saddle	Other
Bermuda a	11+13	1+1	38	10+11	5+3	15	6+9	6+6	54
Bermuda b	9+15	4+2	34	16+16	5+5	45	2+3	5+6	30
Bermuda c	rubbed	rubbed	—	10+9	4+3	27	3+2	3+2	19
Bermuda e	7+6	3+2	36	6+4	4+4	41	0+0	4+3	15
France	16+15	4+2	32	14+16	6+6	41	4+5	6+5	34
Salem	17+13	6+9	46	17+12	9+8	65	7+6	6+5	51
Boston	19+19	6+4	53	18+17	4+4	57	3+2	2+5	34
Boston b	17+18	5+4	50	18+18	6+9	67	6+9	5+7	43
Boston c	18+18	1+4	35	11+13	3+5	31	2+3	2+3	25
Washington	19+13	5+6	32	15+16	4+4	22	4+6	2+5	21

TABLE 2A.

ARTICLES OF ANTENNA I AND OF TARSI OF LEGS I TO IV.

	I ANTENNA		LEG I		LEG II		LEG III		LEG IV	
	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.
Bermuda a	90	93	14+34	16+36	12+32	13+31	11+32	11+32	9+32	9+30
Bermuda b	107	97	—	—	—	—	—	—	—	—
Bermuda c	67	73	—	13+34	13+30	11+29	10+28	—	13+20	—
Bermuda d	93	88	—	—	—	—	—	—	—	—
Bermuda e	67	66	13+28	13+28	11+27	—	9+26	10+26	7+26	—
France	74	66	16+34	15+35	14+33	13+35	12+32	13+32	10+28	12+32
Salem	73	69	15+33	—	12+33	—	12+32	—	10+28	—
Boston a	99	—	—	—	—	—	—	—	—	—
Boston b	76	91	14+36	14+35	13+33	13+34	12+32	13+33	—	11+29
Boston c	74	81	—	—	—	—	—	—	—	—
Boston d	—	—	—	15+32	—	13+30	—	12+29	10+30	10+28
Beaufort	—	91	14+34	15+33	—	13+?	11+30	12+29	9+?	11+25
Texas	80	—	14+34	15+35	13+32	13+32	12+31	12+32	10+30	11+31
Washington	*	*	—	—	—	13+31	—	—	—	11+29

Table 2b.

ARTICLES OF TARSI OF LEGS V TO IX.

	LEG V		LEG VI		LEG VII		LEG VIII		LEG IX	
	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.	Rt	Lft.	Rt.	Lft.
Bermuda a	9+27	8+28	14+18	9+26	8+25	8+30	8+28	8+28	7+28	8+29
Bermuda c	10+28	—	—	7+26	8+26	7+27	7+29	—	—	7+26
Bermuda e	—	8+26	—	7+25	—	—	7+24	—	—	—
France	8+29	10+32	8+31	8+28	—	8+26	8+27	7+31	8+27	8+27
Salem	8+28	—	8+27	—	7+25	—	—	—	—	—
Boston b	8+30	8+32	9+29	8+29	8+?	8+31	8+29	7+29	8+30	8+31
Boston d	9+26	10+29	8+28	9+27	8+28	8+28	8+27	—	—	—
Beaufort	10+26	8+27	8+26	9+?	7+26	—	8+27	—	—	—
Texas	10+28	8+30	—	—	8+28	8+28	8+28	8+28	—	10+26
Washington	9+31	8+32	—	8+29	—	—	7+30	—	—	—

Table 2c.

ARTICLES OF TARSI OF LEGS X TO XIV.

	LEG X		LEG XI		LEG XII		LEG XIII		LEG XIV	
	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.	Rt.	Lft.
Bermuda a	8+28	8+29	7+29	9+?	8+28	8+29	9+?	7+24	9+32	9+33
Bermuda c	7+29	7+27	—	6+30	8+29	—	—	—	—	—
Bermuda e	6+26	—	7+27	11+27	—	7+?	—	—	—	—
France	8+28	8+27	9+30	9+31	—	—	—	9+33	9+38	9+36
Salem	8+29	—	—	7+29	8+29	—	8+32	—	—	—
Boston b	8+30	8+31	8+31	8+30	9+31	9+26	8+35	8+33	13+36	10+39
Boston d	—	—	—	—	—	—	—	—	—	—
Beaufort	—	—	7+29	—	—	—	—	—	—	—
Texas	8+30	8+30	8+28	—	—	—	9+34	10+34	—	10+?
Washington	—	8+31	—	8+30	—	—	—	8+32	—	—

TABLE 3A.

SPINULES OF FEMUR AND TIBIA OF LEG I.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	0	0	0	0	0	0	0	0	2+1
	Lft.	0	0	0	0	0	0	0	0	0	2+1
Bermuda c	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
Bermuda e	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
France.....	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
Salem.....	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
Boston b..	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
Boston d..	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
Beaufort...	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0+1	0
Texas......	Rt.	0	0	0	0	0	0	0	0	0	0+1
	Lft.	0	0	0	0	0	0	0	0	0	0
Wash-ington	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0

TABLE 3B.

SPINULES OF METATARSUS AND OF TARSUS I, AND PEGS OF TARSUS II OF LEG I.

		METATARSUS			TARSUS I	TARSUS II
		d	v	cd		
Bermuda a.....	Rt.........	0	0	0	0	7, 9, 15, 17, 19, 23, 25, 27, 29
	Lft........	0	0	0	0	9, 11, 13, 19, 21, 23, 25, 27, 29
Bermuda c......	Rt.........	—	—	—	—	—
	Lft........	0	0	0	0	14, 16, 18, 20, 22, 24, 26, 28
Bermuda e......	Rt.........	0	0	0	0	9, 11, 13, 15, 17, 19, 21, 23
	Lft........	0	0	0	0	11, 19, 21, 23
France..........	Rt.........	0	0	0	0	10, 12, 14, 16, 18, 20, 22
	Lft........	0	0	0	0	15, 17, 19, 21, 23, 25, 27, 29
Salem..........	Rt.........	0	0	0	0	9, 11, 13, 17, 19, 21, 25, 27
	Lft........	—	—	—	—	—
Boston b........	Rt.........	0	0	0	0	10, 12, 14, 16, 18, 20, 22, 24, 26, 28
	Lft........	0	0	0	0	11, 13, 15, 17, 19, 21, 23, 25, 27
Boston d........	Rt.........	—	—	—	—	—
	Lft........	0	0	0	0	10, 12, 14, 16, 18, 20, 22, 24, 26
Beaufort........	Rt.........	0	0	0	0	10, 12—14, 16—18, 20, 22, 24, 26
	Lft........	0	0	0	0	11, 13, 15, 17, 19, 21, 23, 25, 27
Texas...........	Rt.........	0	0	0	0	12, 14, 16, 18, 20, 22, 24, (26), 28
	Lft........	0	0	0	0	11—13, 15, 17, 19, 21, 23, 25, 27, 29
Washington.....	Rt.........	—	—	—	—	—
	Lft........	—	—	—	—	—

TABLE 4A.

SPINULES OF FEMUR AND TIBIA OF LEG II.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	0	0	0	0	0	0	0	0	5+1
	Lft.	0	0	0	0	0	0	0	0	0	4+1
Bermuda c	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	4	0	0
Bermuda e	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	—	—	—	—	—	—	—	—	—	—
France	Rt.	0	0	0	0	0	0	0	0	0	2+1
	Lft.	0	0	0	0	2	0	0	0	0	2+1
Salem	Rt.	0	0	0	0	0	0	0	0	0	0+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b	Rt.	0	0	0	0	1	0	0	0	0	3+0
	Lft.	0	0	0	0	2	0	0	0	0	2+1
Boston d	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	0	0	0	0	0	0
Beaufort	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	0	0	0	0	0	2+1
Texas	Rt.	0	0	0	0	0	0	0	0	0	0+1
	Lft.	0	0	0	0	0	0	0	0	0	0+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	0	0	0	0	0	0

TABLE 4B.

SPINULES OF METATARSUS AND TARSUS I, AND PEGS OF TARSUS II OF LEG II.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a	Rt.	0	0	0	0	10, 11, 13, 15, 17, 19, 21—24, 26
	Lft.	0	0	0	0	10, 12, 14, 16, 18, 20, 22, 23, 26
Bermuda c	Rt.	0	0	0	0	7, 9, 11, 14, 16, 18, 20, 22, 24, 26
	Lft.	0	0	0	0	15, 17—19, 21, 23
Bermuda e	Rt.	0	0	0	0	10, 12, 14—16, 18, 20, 22
	Lft.	—	—	—	—	—
France	Rt.	0	0	0	0	8, 10, 12, 14, 16, 18, 20, 22, 24, 26
	Lft.	0	0	0	0	9, 11, 13, 15, 17, 19, 21, 23, 25
Salem	Rt.	0	0	0	0	1, 11, 13, 14, 19, 21, 23, 25, 27
	Lft.	—	—	—	—	—
Boston b	Rt.	0	0	0	0	6, 8, 10, 12, 14, 16, 18, 22, 24, 26
	Lft.	0	0	0	0	(10), 12—18, 20—22, 24
Boston d	Rt.	—	—	—	—	—
	Lft.	0	0	0	0	10, 12, 14, 16—18, 20, 22, 24
Beaufort	Rt.	—	—	—	—	—
	Lft.	0	0	0	0	—
Texas	Rt.	0	0	0	0	10, 12, 14, 16, 18, 20, 22, 24, 26
	Lft.	0	0	0	0	8, 10, 12, 14, 16, 18, 20, 22, 24, 26
Washington	Rt.	—	—	—	—	—
	Lft.	0	0	0	0	11, 13, 15, 17, 19, 21, 23

Table 5a.

SPINULES OF FEMUR AND TIBIA OF LEG III.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	0	0	0	0	0	0	0	2	5+1
	Lft.	0	0	0	0	0	0	0	0	3	5+1
Bermuda c	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e	Rt.	0	0	0	0	0	0	0	0	0	0
	Lft.	0	0	0	0	0	0	0	0	0	0
France	Rt.	0	0	0	0	3				1	4+1
	Lft.	0	0	0	0	7			2	2	4+1
Salem	Rt.	0	0	0	0	0	0	0	0	2	2
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b	Rt.	0	0	0	0	7	0	0	0	4	5+1
	Lft.	0	0	0	0	6	0	0	0	3	3+1
Boston d	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	5	0	0	1	0	3+1
Beaufort	Rt.	0	0	0	0	4	0	0	1	3	5+1
	Lft.	0	0	0	0	3	0	0	0	5	2+1
Texas	Rt.	0	0	0	0	0	2	0	1	1	2+1
	Lft.	0	0	0	0	2+1	0	0	3	0	4+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—

Table 5b.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG III.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a	Rt.	0	0	0	1	9, 11—13, 15—17, 19, 21
	Lft.	0	0	0	1	10, 12, 14, 16, 18, 20, 22
Bermuda c	Rt.	0	0	0	0	?
	Lft.	—	—	—	—	—
Bermuda e	Rt.	0	0	0	0	9, 11, 13, 15, 17, 19, 21
	Lft.	0	0	0	0	9, 11, 13, 15, 17, 19, 21
France	Rt.	0	0	0	0	11, 13, 15, 19, 23, 25
	Lft.	0	0	0	0+1	10, 12, 14, 16, 18, 20, 23, 24
Salem	Rt.	0	0	0	1	12, 14, 16, 17, 19, 21, 23, 25, 27
	Lft.	—	—	—	—	—
Boston b	Rt.	0	0	0	0	7, 9, 11, 13, 15, 17, 19, 21, 23, 25
	Lft.	0	0	0	0	10, 12, 14, 16, 18, 20, 22, 24, 26
Boston d	Rt.	—	—	—	—	—
	Lft.	0	0	0	0	11, 13, 15, 17, 19—21
Beaufort	Rt.	0	0	0	0	?
	Lft.	0	0	0	0	?
Texas	Rt.	0	0	0	0	10, 12, 14, 16, 18, 20, 22, 24, 26
	Lft.	0	0	0	0	12, 14, 18, 20, 22, 24, 26
Washington	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—

TABLE 6A.

SPINULES OF FEMUR AND TIBIA OF LEG IV.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	0	0	0	4+1	0	0	7	1	7
	Lft.	0	0	0	0	3	0	0	4	2	4+1
Bermuda c	Rt.	0	0	0	0	0	0	4	0	0	0
	Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e	Rt.	0	0	0	0	4	0	0	4	0	0+1
	Lft.	—	—	—	—	—	—	—	—	—	—
France	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	6+1	0	0	3	5	4+1
Salem	Rt.	0	0	0	0	5+1	0	0	5	5	3
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	7+1	0	0	2	5	5+1
Boston d	Rt.	0	0	0	0	4	0	0	4	4	3+1
	Lft.	0	0	0	0	5	0	0	2	4	5+1
Beaufort	Rt.	0	4	0	0	0+1	0	0	5	6	4+1
	Lft.	0	0	0	4	0	0	0	6	4	4+1
Texas	Rt.	0	0	0	0	4+1	0	0	5	4	3+1
	Lft.	0	0	0	0	5+1	0	0	3	0	4+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	1	0	0	3	0	0	0	1	3

TABLE 6B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG IV.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a	Rt	0	0	3	0	10, 15, 20
	Lft	0	0	0	0	12, 14—16, 18—20, 22, 24
Bermuda c	Rt	0	0	0	0	9, 11, 13, 15, 17
	Lft	—	—	—	—	—
Bermuda e	Rt	0	0	0	0	11, 13, 15, 17, 19, 21
	Lft	—	—	—	—	—
France	Rt					
	Lft	0	0	2	0	16, 18, 19, 21
Salem	Rt	0	0	0	0	16, 18, 20, 22, 24
	Lft	—	—	—	—	—
Boston b	Rt	—	—	—	—	—
	Lft	0	0	3	0	7, 11—13, 15, 17, 19, 21, 23
Boston d	Rt	0	0	0	0	9, 11, 13, 15, 17, 19, 21, 23, 25
	Lft	0	0	0	0	9, 11, 13, 15, 17, 19, 21
Beaufort	Rt	0	0	0	0	?
	Lft	0	0	0	0	10, 12, 14, 16, 18
Texas	Rt	0	0	0	0	11, 13, 15, 17, 19, 21, 23, 25
	Lft	0	0	0	0	10, 12, 14, 16, 18, 20—22, 24, 26
Washington	Rt	—	—	—	—	—
	Lft	0	0	0	0	—

TABLE 7A.

SPINULES OF FEMUR AND TIBIA OF LEG V.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	0	0	0	6	0	0	6	4	7
	Lft.	0	0	0	0	4	0	0	5	4	5+1
Bermuda c	Rt.	0	4	0	0	0	0	0	6	3	4+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	3+1	0	0	3	1	2+1
France.....	Rt.	0	0	0	0	5+2	0	0	4	5	4+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Salem.....	Rt.	0	0	0	0	5+1	0	0	5	7	5
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b..	Rt.	0	0	0	0	8+1	0	0	4	7	5+1
	Lft.	0	0	0	0	7+3	0	0	8	8	7+1
Boston d..	Rt.	0	0	0	0	5+1	0	0	6	5	5+1
	Lft.	0	0	0	0	6+3	0	0	3	3	3+1
Beaufort...	Rt.	0	0	0	0	4+2	2	0	8	0	5+1
	Lft.	0	0	0	0	5+1	2	0	5	6	3+1
Texas......	Rt.	0	0	0	0	5+1	0	0	7	3+1	5+1
	Lft.	0	0	0	0	4+1	0	0	7	7	6+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	0	0	0	3+2	0	0	3	0	4+1

TABLE 7B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG V.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a........	Rt.......	1	0	6	2	9, 10, 14, 15, 17, 20—22
	Lft......	0	0	9	1	10, 12, 14, 16, 18, 24
Bermuda c........	Rt.......	0	0	0	0	?
	Lft......	—	—	—	—	—
Bermuda e........	Rt.......	—	—	—	—	—
	Lft......	0	0	0	0	9, 11, 13, 15, 17, 19, 21
France...........	Rt.......	0	0	5	0	12, 14, 18, 20, 22, 24
	Lft......	—	—	—	—	—
Salem...........	Rt.......	0	0	0	0	16, 18, 20, 22, 24
	Lft......	—	—	—	—	—
Boston b..........	Rt.......	0	0	0	2	12, 14, 16, 18, 22, 24
	Lft......	4	0	9	2	12, 16, 18—20, 22, 24
Boston d..........	Rt.......	0	0	0	0	9, 11, 13, 15, 17, 19, 21
	Lft......	0	0	2	1	16, 18—22
Beaufort..........	Rt.......	1	0	7	4+2+1	12, 14, 16, 18, 20, 22
	Lft......	0	0	5	3+1	11, 15, 17, 19, 21, 23
Texas............	Rt.......	2	0	4	1	14, 18, 20, 22
	Lft......	0	0	6	0	12, 16, 18, 20, 22, 24, 26
Washington.......	Rt.......	—	—	—	—	—
	Lft......	0	0	3	—	14, 16, 18, 20, 22

TABLE 8A.

SPINULES OF FEMUR AND TIBIA OF LEG VI.

	FEMUR					TIBIA				
	d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a Rt.	0	0	0	1	0	1	0	8	5	7
Lft.	0	0	0	10	5+3	0	5	0	0	6+1
Bermuda c Rt.	—	—	—	—	—	—	—	—	—	—
Lft.	0	7	0	0	0+5	7	0	12	0	6+1
Bermuda e Rt.	—	—	—	—	—	—	—	—	—	—
Lft.	0	0	0	0	4+2	0	0	5	2	2+1
France..... Rt.	—	—	—	—	—	—	—	—	—	—
Lft.	0	0	0	0	4+3	0	0	7	7	4+1
Salem..... Rt.	—	—	—	0	7+1	0	—	—	5	5+1
Lft.	—	—	—	—	—	—	0	0	—	—
Boston b.. Rt.	0	0	0	0	7+2	1	1	7	8+1	4+1
Lft.	0	0	0	0	7+1	1	6	8	6+1	7+1
Boston d.. Rt.	0	0	0	0	5+1	2	2	5	3	6+1
Lft.	0	0	0	0	3+3	1	0	6	5	5+1
Beaufort... Rt.	0	0	0	0	3+1	3	1	7	6	4+1
Lft.	0	0	0	0	3+1	2	1	6	4	4+1
Texas...... Rt.	—	—	—	—	—	—	—	—	—	—
Lft.	—	—	—	—	—	—	—	—	—	—
Wash- Rt.	—	—	—	—	—	—	—	—	—	—
ington Lft.	0	2	0	0	4+1	0	0	5	1	5+1

TABLE 8B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF METATARSUS OF LEG VI.

	METATARSUS			TARSUS I	TARSUS II
	d.	v.	cd.		
Bermuda a........ Rt.......	9	0	15	4+0	9, 12, 13
Lft......	7	0	14	3+1	0
Bermuda c........ Rt.......	—	—	—	—	—
Lft......	13	0	16	8+1+1+1	?
Bermuda e........ Rt.......	—	—	—	—	—
Lft......	0	0	5	0	9, 11, 13, 15, 17, 19, 20
France........... Rt.......	—	—	—	—	—
Lft......	4	0	11	6+2+2+2	16, 18, 20, 22
Salem............ Rt.......	0	0+1	11	4	14, 16, 20, 22
Lft......					
Boston b.......... Rt.......	0	0	0	4	11, 15, 17, 19, 21, 23
Lft......	4	0	9	5	12, 14, 16, 18, 22, 24
Boston d.......... Rt.......	5	0	9	2	20, 22, 24
Lft......	7	0	9	3+1	15, 17, 19, 21
Beaufort.......... Rt.......	6	1	11	4+2+1	10, 12—14, 16, 18, 20, 22
Lft......	7	0	9	6+2+2+1	?
Texas............. Rt.......	—	—	—	—	—
Lft......	—	—	—	—	—
Washington....... Rt.......	—	—	—	—	—
Lft......	5	0	6	0	18

TABLE 9A.

SPINULES OF FEMUR AND TIBIA OF LEG VII.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.					4+4	5	5	10	5	7
	Lft.	0	5	0	0	3+3	5	5	9	1	7
Bermuda c	Rt.	0	1	0	0	0+3	2	0	5	0	4+1
	Lft.	0	2	0	3	0+3	3	0	8	4	6+1
Bermuda e	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
France.....	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	1	0	0	2+4	3	1	7	7	4+1
Salem.....	Rt.	?	?	?	?	?	7	?	?	?	?
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b..	Rt.	0	0	0	0	5+4	2	3	7	9+1	5
	Lft.	0	0	0	0	6+3	4	1	9	9	7+1
Boston d..	Rt.	0	2	0	0	3+3	4	3	7	5	5+1
	Lft.	0	3	0	0	4+5	0	4	7	6	5+1
Beaufort..	Rt.	0	0	0	0	2+3	5	1	7	6	5+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas......	Rt.	0	3	0	0	4+4	2	4	8	8	7+1
	Lft.	0	3	0	0	4+5	3	2	8	7	6+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—

TABLE 9B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF METATARSUS II OF LEG VII.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a........	Rt.......	14	2	16	13+2+1+1	0
	Lft......	17	0	15	10+2+1+1	0
Bermuda c........	Rt.......	9	0	12	6+2+1+1	15, 17, 19
	Lft......	7	4	10	1+1	—
Bermuda e........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
France............	Rt.......	—	—	—	—	—
	Lft......	8	0	13	14+1+2+2	0
Salem............	Rt.......	10	0	?	5+0	18, 20
	Lft......	—	—	—	—	—
Boston b..........	Rt.......	11	1	11	5+2	—
	Lft......	11	0	18	8+1+1	17, 19, 21, 23
Boston d..........	Rt.......	10	0	15	6+1	20, 22, 24
	Lft......	12	0	11	6+1	16, 22
Beaufort..........	Rt.......	14	1	15	6+2+2+1	—
	Lft......	—	—	—	—	—
Texas.............	Rt.......	11	0	11	6+2	18, 20, 22, 24
	Lft......	9	0	15	6+1	16, 18, 20, 24
Washington.......	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—

TABLE 10A.

SPINULES OF FEMUR AND TIBIA OF LEG VIII.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	4	0	0+4	0	7	6	9	0	7
	Lft.	0	4	0	1+3	0	8	5	7	4+1	7
Bermuda c	Rt.	0	6	0	0	0+4	6	4	9	3	6+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e	Rt.	0	3	0	0+1	2+3	3	0	6	0	4+1
	Lft.	—	—	—	—	—	—	—	—	—	—
France	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	7	0	0	0+4	9	3	12	6	7
Salem	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b	Rt.	0	5	0	0	1+3	4	2	7	9	6+1
	Lft.	0	3	0	0	5+4	5	4	9	9+2	6+1
Boston d	Rt.	0	7	0	0	1+3	5	5	6	3	5+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Beaufort	Rt.	0	1	0	0	2+3	6	4	9	3	6+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas	Rt.	0	4	0	0	3+4	5	5	0	0	7+1
	Lft.	0	6	0	0	1+5	4	4	8	8	6+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—

TABLE 10B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG VIII.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a	Rt.	18	2	19	13+3+2+1+1	0
	Lft.	17	4	21	12+2+1+1	20, 18
Bermuda c	Rt.	19	3	17	14+1+1+1+1	22, 24
	Lft.	—	—	—	—	—
Bermuda e	Rt.	9	0	12	1	12, 14, 16, 18, 20
	Lft.	—	—	—	—	—
France	Rt.	—	—	—	—	—
	Lft.	17	5	19	17+3+3+2	0
Salem	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—
Boston b	Rt.	14	1	15	11+1+1	15, 21, 23
	Lft.	12	0	20	10+1+1	17, 19, 21, 23
Boston d	Rt.	17	1	?	9+1+1	15, 17, 19, 21
	Lft.	—	—	—	—	—
Beaufort	Rt.	19	3	17	9+2+2+2+2+1	0
	Lft.	—	—	—	—	—
Texas	Rt.	13	2	16	11+2+1	18, 20, 22, 24
	Lft.	16	0	15	8+1	18, 20, 22
Washington	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—

Table 11a.
SPINULES OF FEMUR AND TIBIA OF LEG IX.

		Femur					Tibia				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	7	0	0	1+5	7	6	10	2	8
	Lft.	0	8	0	0	2+3	12	7	8	2+3	12
Bermuda c	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	4	0	0	0+4	7	0	9	0	5+1
Bermuda e	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
France.....	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Salem.....	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b..	Rt.	0	6	0	0	3+4	8	6	9	8+3	7+1
	Lft.	0	6	0	0	5+4	6	5	10	8+4	6+1
Boston d..	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Beaufort...	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas......	Rt.	0	6	0	0	0+4	7	7	10	6	8+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—

Table 11b.
SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG IX.

		Metatarsus			Tarsus I	Tarsus II
		d.	v.	cd.		
Bermuda a.......	Rt.......	23	5	21	17+3+1+1+1	0
	Lft......	23	9	26	14+3+1+1+1	0
Bermuda c........	Rt.......	—	—	—	—	—
	Lft......	15	1	19	16+v+v+o+1	19
Bermuda e........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
France........	Rt......	—	—	—	—	—
	Lft......	—	—	—	—	—
Salem...........	Rt......		—	—	—	—
	Lft......	—	—	—	—	—
Boston b..........	Rt.......	17	3	20	13+1+1	0
	Lft......	20	2	19	15+1+1	23
Boston d..........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Beaufort..........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Texas............	Rt.......	—	—	—	—	—
	Lft......	17	4	21	11+2+1+1	0
Washington	Rt......	—	—	—	—	—
	Lft......	—	—	—	—	—

TABLE 12A.

SPINULES OF FEMUR AND TIBIA OF LEG X.

		Femur					Tibia				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	5	0	0	0+3	8	7	10	1	8
	Lft.	0	6	0	0	0+4	12	8	11	3+3	7
Bermuda c	Rt.	0	5	0	0	0+3	12	8	15	1+2	9+1
	Lft.	0	8	0	0	0+4	7	0	9	0	5+1
Bermuda e	Rt.	0	6	0	0	0+2	0	3	8	0	5+1
	Lft.	—	—	—	—	—	—	—	—	—	—
France	Rt.	0	7	0	0	0+3	7	4	9	0+3	4+1
	Lft.	0	4	0	0	0+3	8	5	7	2	3+1
Salem	Rt.	0	9	0	2	0+4	10	6	10	6+2	8
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b	Rt.	0	8	0	0	1+4	8	8	12	7+4	6+1
	Lft.	0	6	0	0	0+3	10	8	11	6+4	6+1
Boston d	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Beaufort	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas	Rt.	0	9	0	0	1+3	9	8	9	8+2	7+2
	Lft.	0	6	1	0	0+4	9	7	8	9	8+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	8	0	0	0+2	8	6	9	0	5+1

TABLE 12B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG X.

		Metatarsus			Tarsus I	Tarsus II
		d.	v.	cd.		
Bermuda a	Rt.	28	8	27	20+4+1+1+1+1	0
	Lft.	20	6	23	20+3+2+2+0+1	0
Bermuda c	Rt.	19	8	20	14+3+2+1+1	0
	Lft.	15	1	19	14+3+1+0+1	0
Bermuda e	Rt.	28	0	16	8+1+0	17, 19
	Lft.	—	—	—	—	—
France	Rt.	16	4	22	16+3+3+1+2+1	0
	Lft.	18	3	23	16+3+3+2	0
Salem	Rt.	23	5	20	14+2+1+2+1	0
	Lft.	—	—	—	—	—
Boston b	Rt.	22	4	19	18+2+1+1+1	0
	Lft.	25	5	22	15+2+1+1	0
Boston d	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—
Beaufort	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—
Texas	Rt.	18	6	20	17+3+1+1	0
	Lft.	18	6	21	20+2+2+2	0
Washington	Rt.	—	—	—	—	—
	Lft.	19	4	25	18+2+1+1+1+1	0

TABLE 13A.

SPINULES OF FEMUR AND TIBIA OF LEG XI.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	7	0	0	0+6	14	8	12	1	8
	Lft.	0	6	0	0	0+4	10	8	12	0	9
Bermuda c	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	12	0	0	0+4	19	9	15	3+2	9+1
Bermuda e	Rt.	0	7	0	0	0+3	7	4	8	0	6+1
	Lft.	0	7	0	0+1	0+1	10	6	8	0	5+1
France	Rt.	0	8	0	0	0+4	10	6	10	0	4+1
	Lft.	0	5	0	0	0+5	9	6	9	2	4+1
Salem	Rt.	0	8	0	1	0+4	14	8	10	4+2	7
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b	Rt.	0	6	0	0	0+3	11	7	13	6+4	7+2
	Lft.	0	6	0	0	0+3	8	8	12	4+4	7+1
Boston d	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Beaufort	Rt.	0	8	0	0	0+4	12	9	11	3+2	8+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas	Rt.	0	8	0	0	1+4	7	10	10	6+4	8+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	5	0	0	1+2	9	7	11	0	7+1

TABLE 13B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS I OF LEG XI.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a	Rt.	33	11	26	26+3+2+1+1	0
	Lft.	30	11	27	24+4+2+2+1	—
Bermuda c	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—
Bermuda e	Rt.	16	1	13	6+0	0
	Lft.	16	1	17	9+1	0
France	Rt.	19	6	27	22+3+2+2+0+1+2	0
	Lft.	25	4	26	16+3+3+3+2+1	0
Salem	Rt.	28	6	24	17+2+2+1	0
	Lft.	28	8	24	20+1+2+2	0
Boston b	Rt.	25	9	25	20+3+1+1	0
	Lft.	24	8	29	15+2+1+1	0
Boston d	Rt.	—	—	—	—	—
	Lft.	—	—	—	—	—
Beaufort	Rt.	29	10	26	28+4+3+3+2+1	0
	Lft.	—	—	—	—	—
Texas	Rt.	25	9	23	20+2+2	0
	Lft.	—	—	—	—	—
Washington	Rt.	—	—	—	—	—
	Lft.	26	5	24	24+4+2+1+1+1+1	0

TABLE 14A.

SPINULES OF FEMUR AND TIBIA OF LEG XII.

		FEMUR					TIBIA				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	9	0	0	0+6	16	13	14	1	12
	Lft.	0	8	0	2	0+5	12	11	13	2+4	8
Bermuda c	Rt.	0	5	0	0	0	14	10	14	0+3	8+1
	Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
France.....	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Salem.....	Rt.	0	1	1	2	0+5	15	12	15	6+4	10
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b..	Rt.	0	7	0	0	0+3	12	11	15	0+4	9+1
	Lft.	0	8	0	0	0+5	13	9	13	5+3	7+1
Beaufort...	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas......	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—

TABLE 14B.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG XII.

		METATARSUS			TARSUS I	TARSUS II
		d.	v.	cd.		
Bermuda a........	Rt.......	34	15	33	30+3+2+2+1+1	0
	Lft......	28	16	29	28+2+3+3+3+1	0
Bermuda c........	Rt.......	28	10	22	22+5+2+2+2+2+1	0
	Lft......	—	—	—	—	—
Bermuda e........	Rt.......	—	—	—	—	—
	Lft......	19	1	13	11+0+1	0
France..........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Salem............	Rt.......	30	7	29	26+2+2	0
	Lft......	—	—	—	—	—
Boston b.........	Rt.......	27	6	31	21+3+3+1+2	0
	Lft......	30	8	30	22+3+2+2+1+1	0
Beaufort..........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Texas.............	Rt.......	—	—	—	—	—
	Lft.	—	—	—	—	
Washington.......	Rt.......	—	—	—	—	—
	Lft	—	—	—	—	

Table 15a.

SPINULES OF FEMUR AND TIBIA OF LEG XIII.

	FEMUR					TIBIA				
	d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a Rt.	0	12	0	4	0+7	21	13	15	0	14
Bermuda a Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda c Rt.	—	—	—	—	—	—	—	—	—	—
Bermuda c Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e Rt.	—	—	—	—	—	—	—	—	—	—
Bermuda e Lft.	—	—	—	—	—	—	—	—	—	—
France..... Rt.	—	—	—	—	—	—	—	—	—	—
France..... Lft.	0	7	0	0	2+4	16	10	14	0+2	8+1
Salem..... Rt.	0	10	0	5	2+6	19	14	18	12+4	14
Salem..... Lft.	—	—	—	—	—	—	—	—	—	—
Boston b.. Rt.	0	8	0	0	0+5	12	13	16	4+4	8+1
Boston b.. Lft.	0	8	0	0	2+5	15	10	14	5+4	9+1
Beaufort... Rt.	—	—	—	—	—	—	—	—	—	—
Beaufort... Lft.	—	—	—	—	—	—	—	—	—	—
Texas...... Rt.	0	9	0	0	1+7	18	14	13	7+4	12+1
Texas...... Lft.	0	12	2	2	1+5	15	15	15	13+2	11+1
Washington Rt.	—	—	—	—	—	—	—	—	—	—
Washington Lft.	0	5	0	0	1+2	12	9	6	0+3	5+1

Table 15b.

SPINULES OF METATARSUS AND TARSUS I AND PEGS OF TARSUS II OF LEG XIII.

	METATARSUS			TARSUS I	TARSUS II
	d.	v.	cd.		
Bermuda a........ Rt.......	36	16	33	35+4+4+2+2+1	—
Bermuda a........ Lft......	—	—	—	—	—
Bermuda c........ Rt.......	—	—	—	—	—
Bermuda c........ Lft......	—	—	—	—	—
Bermuda e........ Rt.......	—	—	—	—	—
Bermuda e........ Lft......	—	—	—	—	—
France............ Rt.......	—	—	—	—	—
France............ Lft......	20	12	30	25+3+2+3+2+1	0
Salem............ Rt.......	30	12	28	29+3+1	0
Salem............ Lft......	—	—	—	—	—
Boston b.......... Rt.......	28	9	30	22+3+3+2+1	0
Boston b.......... Lft......	33	8	31	25+3+2+1	0
Beaufort.......... Rt.......	—	—	—	—	—
Beaufort.......... Lft......	—	—	—	—	—
Texas............. Rt.......	25	14	29	26+2+3+1+1	0
Texas............. Lft......	25	13	33	26+4+3+1+1	0
Washington....... Rt.......	—	—	—	—	—
Washington....... Lft......	28	7	29	22+5+5+2+0+1	0

Table 16a.

SPINULES OF FEMUR AND TIBIA OF LEG XIV.

		Femur					Tibia				
		d.	v.	cd.	cm.	cv.	d.	v.	cd.	cm.	cv.
Bermuda a	Rt.	0	4	16	6	14+7	24	14	19	3	13
	Lft.	0	12	8	17	2+6	21	13	17	4+4	14
Bermuda c	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Bermuda e	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
France.....	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	11	0	3	13+4	16	12	13	0+2	11+1
Salem.....	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Boston b..	Rt.	0	10	6	0	13+4	19	15	19	9+4	13+4
	Lft.	0	10	6	0	10+6	15	10	14	5+4	9+1
Beaufort...	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—
Texas......	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	0	10	7	0	15+6	19	14	18	11+5	12+1
Washington	Rt.	—	—	—	—	—	—	—	—	—	—
	Lft.	—	—	—	—	—	—	—	—	—	—

Table 16b.

SPINULES OF METATARSUS AND TARSUS I OF LEG XIV.

		Metatarsus			Tarsus I	Tarsus II
		d.	v.	cd.		
Bermuda a........	Rt.......	39	18	35	30+4+2+2+2+2+2	0
	Lft......	38	20	33	?	0
Bermuda c........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Bermuda e........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
France............	Rt.......	—	—	—	—	—
	Lft......	28	9	30	26+3+3+3+2+1	0
Salem............	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Boston b..........	Rt.......	33	15	28	24+2+2+1	0
	Lft......	32	10	31	25+3+0+1+1	0
Beaufort..........	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—
Texas.............	Rt.......	—	—	—	—	—
	Lft......	34	13	31	27+3+2+1	0
Washington.......	Rt.......	—	—	—	—	—
	Lft......	—	—	—	—	—

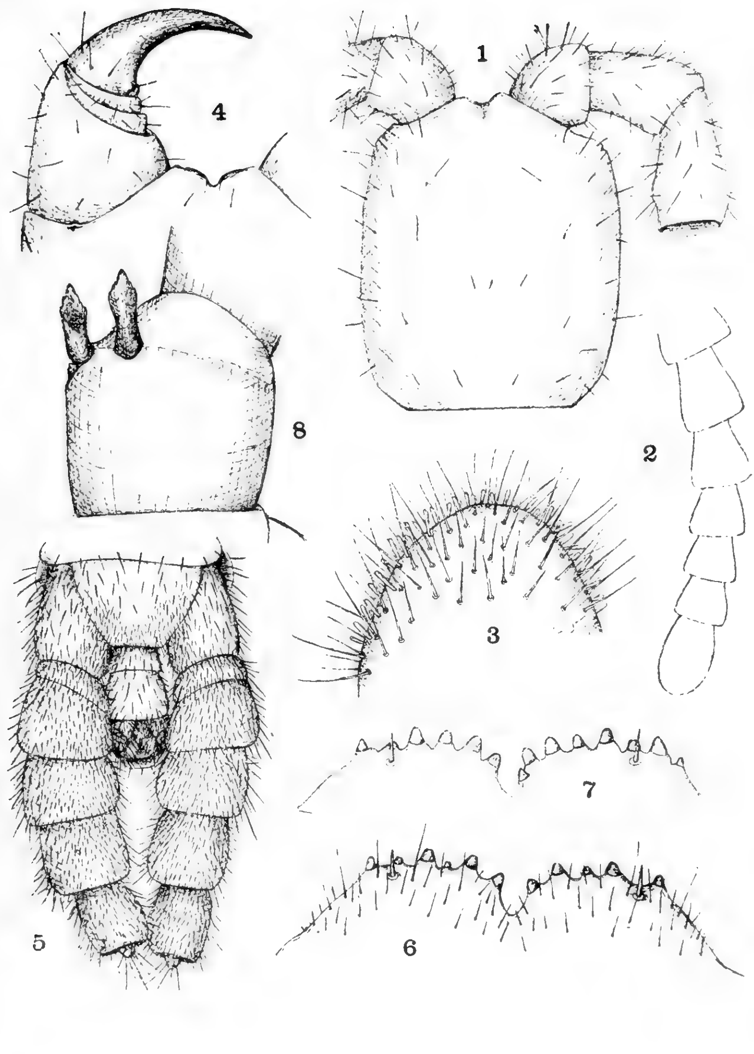
EXPLANATION OF PLATE XXIX

Hydroschendyla submarina (Grube). Male

Fig. 1. Cephalic plate.
Fig. 2. Distal portion of antenna in outline.
Fig. 3. Tip of distal article of antenna more highly magnified.
Fig. 4. Anterior border of prosternum with right prehensor.
Fig. 5. Caudal end with anal legs, ventral view.

Lithobius provocator Pocock.

Fig. 6. Anterior border of prosternum showing position of spine, with tooth interpolated in diastema of right half.
Fig. 7. The same, with tooth interpolated in diastema on both sides and an extra ectal tooth on left half.
Fig. 8. Basal joint of female gonopod showing form of basal spines.



R. V. Chamberlin

REVIEW OF THE NEARCTIC TETANOCERIDÆ.*

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The flies of this family are commonly encountered in meadows and along marshy shores, some species being quite abundant. Their delightful colors, with prevailingly reddish body and frequently pictured wings, make them preferred insects with collectors. As their nomenclature has passed through such revolutionary changes since the publication of Aldrich's Catalog, fifteen years ago, the writer prepared a synopsis of the group to help with their identification. As a curious coincidence, about six months after the manuscript was sent away for publication, an unexpected revision of the same group by E. T. Cresson, Jr., appeared in the Transactions of the American Entomological Society. The publication of several of the new genera and species diagnosed in my manuscript made it necessary to recall the copy from the editor and to revise it. To make the tables complete, Cresson's new genera and species and additional localities cited by him have been incorporated. I am also indebted to Cresson for the information concerning the prior use of *Euthycera* Latreille over *Lunigera* Hendel. Aside from these changes, the nomenclature previously decided upon I have retained. A comparison of the two papers will disclose a few instances where we do not agree. Most of these concern the identification of European species. It is interesting to note that independently, without knowing of the other's work, we both arrived at the same conclusions so many times. For example, Mr. Cresson's new genera, *Hoplodictya* and *Dictyomyia*, based on previously known species, were likewise described as new by me.

Mr. Cresson's studies were based mainly on Eastern material, while the present paper, dealing entirely with my own collection, is based principally on Western forms. The combination of the two, therefore, brings to light so much new material and so many changes in nomenclature that the list in Aldrich's Catalog now seems antiquated. Aldrich listed fifty species and seven genera from north of Mexico as coming in this family. Of these,

* Contribution from the Zoology Laboratory of the State College of Washington.

six species have been dropped as unrecognizable, eight have been relegated to synonymy and twenty-four have been assigned different generic names, leaving but twelve remaining unchanged. In the following pages are given synoptic keys to twenty-two genera, eighty-nine species and eight varieties. Cresson's paper enumerates fifty-five species and seven varieties, distributed among twenty genera.

The family designation, Tetanoceridæ, has been chosen instead of the name Sciomyzidæ, because *Tetanocera* Dumeril, 1798, antedates *Sciomyza* Fallen, 1820. Even the genera *Dictya* Meigen, 1803, and *Sepedon* Latreille, 1804, have claim for recognition prior to *Sciomyza*. The forms grouped about *Dryomyza* are sometimes segregated as a distinct family, the Dryomyzidæ, but while they have a somewhat characteristic habitus, their differences are hard to express in terms of family value.

In the following pages are given in dichotomic form identification tables for the genera and species of Tetanoceridæ known from north of Mexico. Only in cases where genera or species are not listed in Aldrich's Catalog a bibliography has been included; where species have been assigned to genera other than in the Catalog the former name is given in parenthesis; page references to Cresson's paper are quoted following his name. Localities represented in my collection are designated by an asterisk (*).

The valves of the hypopygium, called paramera by Hendel, sometimes afford splendid characters for identification. The genitalia must be disengaged in order to obtain a view of these appendages, which in old specimens can be readily accomplished by relaxing and pulling down the hypopygium. Examination of the valves, especially in species of *Tetanocera*, where they are large, affords a ready means of certain identification. It may be that such an examination of the American specimens referred to *T. elata*, *ferruginea* and *silvatica* will disclose that these European species do not occur in this country.

With reference to the identification of other European species, the extended distribution of some, such as *Neuroctena anilis*, *Melina nana* and *grisescens*, has long been known. Flies that have so distinctive and frequent a habitat as the marshy shores of ponds often have a wide distribution. The prevalence of European species on the Pacific slope is not

surprising. Notwithstanding opinions to the contrary, I feel it a safer course to use existing European names for such species rather than to describe as new forms that are specifically indistinguishable.

Table of the Genera of Tetanoceridæ.

Clypeus prominent, not retractable with the infolding of the proboscis, usually chitinized and narrow; first vein ending beyond middle of wing; femora finely pilose, with bristles undeveloped. (Dryomyzinæ)........ 3

Clypeus vestigial, rarely chitinized, not touching oral margin when proboscis is extended; first vein ending at middle of wing; femora setulose, their bristles developed; species occurring in moist meadows and along the shores of ponds.......... 2

2. A distinct bristle present above base of front coxæ (indistinct in *Melina pubera*); front without differentiated median polished stripe, except in *Ditænia*. (Sciomyzinæ).......... 6

Propleural bristle wanting; front with a distinct polished median stripe, rarely subshining. (Tetanocerinæ).......... 9

3. Wings with costal spines; eyes small, the cheeks broader than the eyes; face not excavated in profile; antennæ not reaching halfway to the mouth-opening; scutellum flat and setulose; pollinose maritime species. *Helcomyza* Curtis

Costa not spinose; eyes deeper than the cheeks; face shorter, and excavated in profile, the antennæ nearly attaining oral margin; scutellum convex and bare.......... 4

4. Dorsocentrals extending in front of the imperfect suture; 6 scutellars; 2 fronto-orbitals; underside of proboscis with saucer-like base; opaque black glaucous pubescent maritime species............ *Heteromyza* Fallen

Transverse suture distinct; 2 dorsocentrals present; 4 scutellars; 1 fronto-orbital; proboscis narrow; middle tibiæ with posterior bristles; subshining reddish woodland species.......... 5

5. Veins bare, hairs of first vein microscopic............ *Dryomyza* Fallen

First vein closely and obviously hairy............ *Neuroctena* Rondani

6. Front tibiæ with 2 approximate preapical bristles; hind femora of both sexes beneath typically with an outstanding bristle.......... 7

Front tibiæ with 1 preapical bristle; at most the hind femora of male short-spinose or hairy.......... 8

7. Arista densely short white plumose; face tuberculate above. *Oidematops* Cresson

Arista black and long-plumose; face not tuberculate....... *Sciomyza* Fallen

8. Small, shining black species with polished front and narrow cheeks; legs yellow, the front pair largely black and with lengthened coxæ. *Pteromicra* Lioy

Yellow to gray, opaque or subshining, never shining black species, with broader cheeks and shorter front coxæ.............. *Melina* Desvoidy

9. Scutellum with 4 bristles, (2 in *Hemitelopteryx johnsoni*); chætotaxy better developed than in *Sepedon;* hind femora not much longer than the abdomen; second antennal joint shorter or at least not longer than third, longer only in *Dictyomyia*.......... 10

Scutellum with 2 bristles, no ocellar, humeral, presutural, prescutellar, pleural or abdominal bristles; hind femora greatly surpassing the abdomen; second antennal joint longer than third; lunule free. *Sepedon* Latreille

10. Third antennal joint oval, three times the length of the second; front more or less constricted toward antennæ.......... 11

Third antennal joint rarely oval, usually more or less triangular, flattened or excised above, the second joint relatively much longer; sides of front nearly parallel.......... 13

11. Slender species with short and narrow wings; two scutellars, one dorsocentral; arista densely short black-plumose........*Hemitelopteryx* Cresson
    Wings larger, surpassing the abdomen; four scutellars....................12
12. One preapical bristle on hind tibiæ; hypopygium moderate, fifth sternite simple; hind femora closely spinose beneath; first vein ending beyond anterior crossvein; cheeks at least half as wide as eye....*Renocera* Hendel
    Two preapical bristles on hind tibiæ; hypopygium enlarged, fifth sternite pointed; first vein ending opposite or before anterior crossvein; cheeks not exceeding one-third the eye........................*Antichæta* Haliday
13. At least meso- and pteropleuræ with macrochætæ; face nearly vertical, its central part with nearly parallel sides; wings brown, with paler spots; eyes vertically oval..14
    No distinct macrochætæ on pleuræ, sometimes setulæ present; face more or less receding and divergent below; 2 reclinate fronto-orbitals........15
14. Two fronto-orbitals, the anterior proclinate, 1 sternopleural, 3 dorsocentrals; second antennal joint with a forcipate pair of stout bristles; fourth tergite of ♂ narrow........................*Hoplodictya* Cresson
    One fronto-orbital, 0 sternopleural, 2 dorsocentrals; second antennal joint with only ordinary setæ; fifth tergite narrow........*Dictya* Meigen
15. Arista almost bare; hind crossvein strongly bent, S-like; scattered setulæ on meso-, sterno- and pteropleuræ; wings with few markings; lunule visible..16
    Arista pubescent or plumose; hind crossvein sinuous or arcuate; 2 or 3 dorsocentrals..17
16. No vallar bristles, i. e., on callosity beneath calypteres, 0 presutural, 0 prescutellar, 1 dorsocentral; extensor femoral bristles weak. *Hedroneura* Hendel
    Vallar bristles present, 1 presutural, 1 prescutellar, 2 dorsocentrals; front femora bristly above............................*Elgiva* Meigen
17. First vein ending almost opposite anterior crossvein; interfrontal stripe depressed and relatively narrow; 2 dorsocentrals; edges of second antennal joint nearly parallel....................................18
    First vein ending far before anterior crossvein; interfrontalia convex, five times as broad as periorbit; 3 dorsocentrals; second antennal joint compressed, obconical, half as long as the scimiter-shaped third joint, arista plumose; all pleural sclerites setulose; wings brown, with rounded clear spots.............................*Poecilographa* Melander
18. Meso- and pteropleuræ entirely bare, no vallar bristles, only the sternopleuræ setulose..19
    Meso- and pteropleuræ as well as sternopleuræ bearing setulæ, vallar bristles (i. e., on callosity beneath calypteres) present; eyes transversely oval; fifth tergite of male wide; lunule covered; wings reticulate...21
19. Lunule exposed; wings brown, with rounded clear spots...................20
    Lunule more or less covered; wings nearly uniformly colored, the crossveins clouded, sometimes with short transverse marks, but no round clear spots; eyes round; arista black-plumose; fifth tergite wide. *Tetanocera* Dumeril
20. Second antennal joint slender, as in *Sepedon*, much longer than the third; eyes vertically oval; arista white-pubescent; wings abnormally wide; fifth tergite ♂ wide; face tuberculate beneath antennæ..*Dictyomyia* Cresson
    Second antennal joint quadrate and broad, scarcely longer than third; eyes round; arista white-plumose; fifth tergite ♂ retractile; face carinate just beneath antennæ......................*Euthycera* Latreille
21. Arista loosely black-plumose; interfrontal depression not polished. *Trypetoptera* Hendel
    Arista closely white-pubescent or short-plumose; interfrontal stripe shining..*Limnia* Desvoidy

Heteromyza Fallen.

Heteromyza Fallen, Dipt. Suec. Heteromyz, 2 (1820). Not *Heteromyza* of authors (Helomyzidæ) which is *Heteromyiella* Hendel, 1910.
Heterostoma Rondani, Prodr. Dipt. Ital. I, 104 (1856).
Heterocheila Rondani, Prodr. Dipt. Ital. II, 13 (1857).
Oedoparea Loew, Zts. Entom. Breslau, XIII, 10 (1859).
Exocheila Rondani, Prodr. Dipt. Ital. VII, Sciomyz, 72 (1866).

Black, only the halteres yellow; front, mesonotum and scutellum brown pruinose, occiput, pleuræ, abdomen and legs blue-gray; veins and margins of calypteres black; 5 dorsocentrals; body and legs of male with long black hairs; 6-7 mm. Alaska, Washington.* (*Oedoparea*)... **glauca** Coquillett

Helcomyza Curtis.

Helcomyza Curtis, Brit. Ent. 68 (1825).
Actora Meigen, Syst. Beschr. V, 403 (1826).

Helcomyza mirabilis n. sp.

Female—Length 7–11 mm. Face, cheeks and lower occiput thickly overlaid with silvery white pollen, front convex and golden-olivaceous pollinose, two rather small fronto-orbital bristles, antennæ black, third joint orbicular, arista short, bare and black, mouthparts black, head with fine hairs which are short and proclinate on the front and outstanding on the cheeks. Thorax thickly coated with pollen, olivaceous gray on anterior mesonotum, usually purer gray about the scutellum, vaguely marked with seal-brown vittæ comprising a central pair stronger at each end and a broader, shorter and darker lateral pair interrupted along the transverse suture, most of the setulæ arising from a brown dot, pleuræ cinereous, a velvet-black spot around the anterior spiracle; chætotaxy as follows: 1 humeral, 2 notopleural, 1 presutural, 1 supra-alar, 2 intra-alar, 3 dorsocentral, 2 prescutellar, 4 scutellar, 0 pleural except 1 pro-pleural and a superior row of 5 spernopleural bristles, mesonotum and scutellum setulose, pleuræ bare except for rather dense and long outstanding fine black hairs covering the sternopleuræ. Abdomen cinereous, with fine black hair, seven segments visible. Legs hairy, the femora piceous and cinereous pollinose, tibiæ brown, tarsi brown at base, apically black, front femora with six flexor hairs longer than the rest, middle tibiæ with about ten rather strong bristles irregularly placed in addition to the usual preapical crown of bristles; front and hind tibiæ with single preapical bristle. Halteres and calypteres yellow. Wings hyaline, veins fine and black, base of costal cell and all crossveins margined with strong infumation, a brown spot crossing the middle of the first basal cell, costal sections beyond humeral vein proportioned 4 : 4 : 4 : 3 : 2, third and fourth veins drawn together at anterior crossvein, which is located at five-ninths the length of the discal cell, anal vein straight, ending under middle of discal cell.

Male—10–13 mm. Hairs of palpi, cheeks, body and legs much longer, those of sternopleuræ, abdomen and femora tipped with golden; 1 dorsocentral, prescutellars reduced, propleuræ of largest specimens

with a pencil of hairs, no distinct sternopleurals, no preapicals, bristles of middle tibiæ more numerous, inside of front and hind tibiæ and plantar surface of their tarsi with dense dark-orange sole.

Helcomyza mirabilis n. sp. Male.
(Enlarged 3 diameters.)

The first specimens of this remarkable species were discovered in May, 1917, actively flying over the dry sands along the seabeach near Ilwaco, Washington. Additional specimens were taken on later visits to the same locality in July and August of the same year, and in 1918, with the help of Anthony Spuler and Miss Orilla E. Miner, enough specimens from the same locality were captured to bring the collection up to eighty individuals. The flies were difficult to catch, being alert and quick to take to the wing, and with the sea breeze blowing, were carried many feet along the sands before they would alight. The males vary greatly in stature and vestiture, the largest specimens being quite shaggy. This fine species is one of the largest of the American Acalypteræ.

Actora ferruginea Walker, from Nova Scotia, is omitted from the present discussion, as it clearly does not belong to the Tetanoceridæ.

Dryomyza Fallen.

Dryomyza convergens Walker, from Nova Scotia, is omitted from the following table, since it almost certainly belongs elsewhere. It has the thorax trivittate, the posterior crossvein clouded, the arista downy, and the abdomen furnished with short black bristles.

Wings with marginal cell, apex and crossveins distinctly marked with dark brown; first posterior cell two-thirds as wide as the submarginal along the costa; no distinct posterior setæ on middle tibiæ. Idaho,* Alaska*.. **maculipennis,** n. sp.
Wings not pictured; middle tibiæ with distinct posterior setæ........... 2
2. Third vein recurved, ending beyond wing-tip, the submarginal cell twice as wide as the first posterior along the costa; pilosity of arista very fine and rather sparse. N. Y.,* B. C. (Cresson, 34).......... **dayi** Cresson
Third vein less recurved, the first posterior cell two-thirds as wide as the submarginal along the costa; arista blackish and distinctly pilose; hypopygium large. Vt.*................................ **ferruginea,** n. sp.

Dryomyza maculipennis new species.

Length 5-7 mm. Entirely shining luteous, the tarsi black, front opaque orange, pubescence fine, of front and notum blackish, of sternopleuræ and abdomen long and yellow, of tarsi blackish. Arista loosely hairy, black except at base. Three hair-like black sternopleurals. Middle tibiæ with at most one posterior seta. Veins yellow, but black around the infuscations which include the costal cell, the apex of the wing and the anterior, posterior and anal crossveins, anal crossvein reflexed, third vein gently curving back, ending just behind the wing-tip, parallel with the fourth vein, costal sections beyond the humeral crossvein proportioned 3 : 4 : 5 : 3 : 2.

Nineteen specimens; Avon, Moscow, Waha, Idaho;* Douglas, Alaska* (Jenne).

Dryomyza ferruginea new species.

Male—Length, 5 mm. Ferruginous, shining, middle of abdomen brown, front opaque reddish yellow, pubescence fine, abundant, colored as in the other species. Two fronto-orbitals; antennæ reddish. Two long black sternopleural hairs. Hypopygium large, the paramera hook-like, the penis thick, black, and when exserted curved around the right side of the hypopygium. Middle tibiæ with two or three small posterior setæ, less distinct in the female. Halteres testaceous. Wings with a yellowish tinge, veins yellowish brown, a slight indication of clouding at the apex and about the anterior and posterior crossveins, third vein gently curved, parallel with the fourth and ending at the wing-tip, costal sections proportioned 5 : 5 : 6 : 4 : 3, anterior crossvein nearly transverse.

Two specimens. Lyndon, Vermont,* August 22, 1900.

Neuroctena Rondani.

First vein entirely hairy; yellow species................................ 2
First vein bare toward base; wings uniformly infumated; arista uniformly pubescent; reddish species with blackened abdomen. Col., N. Mex., Mont.,* Id.,* Wash.,* B. C........................ **fumida** Coquillett
2. Crossveins and apices of third and fourth veins clouded; arista nearly bare; a small black spot beneath calypteres. Eur.;* Mass.,* N. H., Ct., Vt.,* N. Y.,* N. J., Queb.,* Ont.,* Mich., Wis., S. D. (Aldrich), Wash.,* Or. (Cole), B. C.,* Alaska.* (*Dryomyza pallida* Day). **anilis** Fallen
Veins not clouded except faintly about posterior crossvein; arista closely plumose; pteropleural spot weak. Mid. States; Pa. (Hough); N. Y., N. J., Ont.* (*Dryomyza*)................................ **simplex** Loew

Sciomyza Fallen.

Sciomyza Fallen, not of authors, which becomes *Melina* Desv.
Bischofia Hendel, Abhandl. z. b. Ges. Wien, II, 52, (1902).

Largely shining black, the head, pleuræ, scutellum and abdomen laterally reddish to yellow; legs black, the middle pair yellow, except femora apically, the hind femora yellow toward base; arista sparsely plumose; veins bordered with brown, anterior crossvein beyond end of first vein; mesopleuræ bare. Queb., Ottawa. (*Bischofia varia* Coq., Can. Ent. XXXVI, 12, 1904)..**varia** Coquillett

Largely reddish species with reddish legs, the front pair with black tibiæ and tarsi, blackened femoral spot toward apex and paler knees; wings hyaline or apically infumated, anterior crossvein opposite end of first vein; mesopleuræ with posterior row of setulæ........................ 2

2. Center of face polished and blackish; palpi apically blackish; plumosity of arista dense; 1 or 2 pteropleural bristles. Ottawa, Que., Me.,* N. H., N. Y., Mich. (*Dryomyza*)....................**aristalis** Coquillett

Face white pruinose and yellow; a pruinose stripe above notopleural suture, center of notum olivaceous, lower pleuræ pruinose; palpi yellow; plumosity of arista loose; usually 3 pteropleurals. Eur.; Mont.,* Wash.* (*Sciomyza simplex* Fall., Dipt. Suec. Sciomyz. 12, (1820); Meigen, Syst. Bes. VI, 10 (1830); Macquart, Suit. Buff. II. 405, (1835); Zetterstedt, Dipt. Sc. V. 2090, (1846); Schiner, Faun. Austr. II, 46 (1864); Rondani, Prodr. Dipt Ital. VII. Sciomyz. 39 (1868); Hendel, Abh. z. b. Ges. Wien, II. 53 (1902))......................**simplex** Fallen

Pteromicra Lioy.

Pteromicra Lioy, Atti. Instit. Veneto, IX, 1011 (1864).
Dichrochira Hendel, Abhandl. z. b. Ges. Wien, II, 57 (1902).

Two fronto-orbitals; wings only slightly longer than abdomen and narrow, the anal vein about one-third the length of the underside of the discal cell; front tarsi black. Subgenus *Pteromicra* Lioy. Eur.; Siberia; Alaska. (*Sciomyza*)....................................**glabricula** Fallen

One fronto-orbital; wings longer and usually broader, the anal vein about half the length of the underside of the discal cell. Subgenus *Dichrochira* Hendel.. 2

2. Arista thickly pubescent; head entirely black except on the pruinose facial orbits; palpi black.. 3

Arista loosely pubescent; head more or less reddish at least near frontal suture.. 4

3. Arista bushy, black, the antennæ reddish; front tarsi entirely black; hypopygium large; wings broad. Yellowstone Park.*... **melanothrix,** n. sp.

Arista white, the third antennal joint black; last 2 or 3 joints of front tarsi white; hypopygium small; wings narrow. Wash.,*..**leucothrix,** n. sp.

4. Palpi yellow; last 1 or 2 joints of front tarsi white...................... 5

Palpi and third antennal joint black; apical 3 joints of front tarsi white. Mass. (*Dichrochira albicalceata* Cresson, 39)..........**albicalceata** Cresson

5. Head largely yellow; front femora yellow only on basal portion; humeri, notopleural suture, scutellum and pleuræ brownish. H. B. T.; Wash.,* Mass., D. C. (*Sciomyza*)...............................**apicata** Loew

Head largely black; front femora two-thirds yellow; thorax altogether black. Eur.; Pa., Ill., Wisc.,* Wyom.,* Mont.,* Id.,* Wash.* (*Sciomyza nigrimana* Mg., Syst. Bes. VI, 14 (1830); Schiner, Faun. Austr. II, 45 (1864); Rondani, Prodr. Dipt. Ital. VII, Sciomyz, 42 (1868); Hendel, Abh. z. b. Ges. Wein, II, 58 (1902). *Dichrochira pleuralis* Cresson, 39)..**nigrimana** Meigen

Pteromicra melanothrix new species.

Male—Length, 4 mm. Head, including mouthparts, thorax, abdomen, front legs beyond basal three-fifths of femora, and apex of hind femora black, shining on body, dull on legs, antennæ, base of front legs, posterior legs, halteres and calypteres yellowish, two white pruinose occipital spots. Third joint of antennæ rounded-quadrate, the arista but slightly longer than the antenna, its basal joint thick and one-fourth the length of the arista. Lower pleuræ lightly white pruinose, a faint indication of three brown-dusted vittæ on mesonotum. Abdomen with short pubescence, hypopygium globose. Front femora bearing three small extensor bristles on apical half and hind femora bearing two. Wings a little grayish, veins blackish, the anterior veins brown, posterior crossvein slightly clouded, wings less than three times as long as wide, widest opposite anterior crossvein, first vein ending beyond anterior crossvein and at middle of wing, costal sections proportioned 1 : 1 : 2.5 : 0.9 : 0.6, of fourth vein, 1 : 1 : 1.7.

One specimen. Yellowstone Lake, Wyoming,* August 9, 1918.

Pteromicra leucothrix new species.

Length, 2–3 mm. Head, including mouthparts and third antennal joint, and front legs between the basal three-fifths of the femora and the apical two or three joints of the tarsi black, the body polished, base of antennæ, remainder of legs and halteres yellow, apical joints of front tarsi and arista white, occiput not pruinose. Third joint of antennæ elliptical, the arista twice as long as the antenna, its basal joint short. Lower pleuræ very lightly pruinose. Front femora with three and hind femora with two small bristles above toward apex. Wings nearly four times as long as wide, widest opposite posterior crossvein, nearly hyaline, veins blackish, second vein abnormally long, the costal sections proportioned 1 : 0.6 : 6 : 1 : 0.6, sections of fourth vein, 1 : 1 : 2.

Five specimens. Mount Constitution, Orcas Island, Washington,* July, 1919.

Melina Desvoidy. (*Sciomyza* of authors).†

Melina Desvoidy, Myodaires, 695 (1830).
 Arina Desvoidy, same, 696 (1830).
 Chetocera Desvoidy, same, 697 (1830).
Pherbellia Desvoidy, Myodaires, 696 (1830).
 Dyctia Desvoidy, same, 693 (1830).
 Ditænia Hendel, Abhandl. z. b. Ges. Wien, II, 66 (1902).
Graphomyzina Macquart, Hist. Nat. Ins., Dipt. II, 558 (1835).
Atrichomelina Cresson, Tr. Am. Ent. Soc. XLVI, 40 (1920).
 Achætomelina Cresson, same, 30 (1920).

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† This dominant genus includes most of the species listed in Aldrich's Catalog under *Sciomyza*. Of the several generic names proposed by Desvoidy, *Dyctia* has page precedence, but because of its similarity to *Dictya* Meigen, of the same family, the name *Melina* adopted by Hendel and Cresson, is here used.

No median polished stripe on the front, the opaque frontal area not bisected. 2
A stripe usually polished on the middle of the front continuing the ocellar triangle nearly or quite to the antennæ. Subgenus *Pherbellia* Desvoidy . . 17

2. Wings not pictured, at most the crossveins clouded 3
Wings marked with spots or bars in addition to cloudings about the crossveins; femora and tibiæ of posterior legs centrally annulate. Subgenus *Graphomyzina* Macquart 15

3. Two or three fronto-orbitals; mesopleura bare or with posterior setulæ; propleural bristle evident. Subgenus *Melina* Desvoidy 4
But one fronto-orbital; mesopleuræ uniformly pubescent; 0 coxal or abdominal bristles; propleural bristle reduced; ochraceous species with testaceous legs, the front metatarsi white; ♂ abdomen with fine close pubescence. Subgenus *Atrichomelina* Cresson. Mass.,* Ct., N. Y., Pa., D. C.,* Va., Fla.,* Ill.,* Wisc.,* La.,* S. D.,* Kans.,* Tex.,* Mont.,* Id.,* Wash.,* Or.,* Cal.* (*Sciomyza*) . . . . . . **pubera** Loew

4. Bristles of head strong, 3 fronto-orbitals or the anterior midway between suture and posterior bristle; crossveins clouded; arista nearly bare; legs slender, front pair black, posterior pairs brown; largely gray species. Middle States; Me., Mass. (Hough), Md. (*Sciomyza*) . . . . . **tenuipes** Loew
Two fronto-orbital bristles 5

5. Mesopleuræ with a row of setulæ along the posterior margin 6
Mesopleuræ entirely bare of microscopic hairs 8

6. Occiput, thorax and abdomen, including hypopygium gray piceous, notum with 4 narrow brown vittæ, visible from in back, abdomen with paler incisures; front legs mostly black, posterior legs brown; wings nearly hyaline, the crossveins somewhat clouded; halteres yellow; 3–4 mm. Eur.;* Mont.,* Wyo.* (*Sciomyza griseola* Fall., Dipt. Suec. Sciomyz, 14 (1820); Meigen, Syst. Bes. VI, 13 (1830); Macq. Suit. Buff. II, 406 (1835); Zetterstedt, Dipt. Sc. V, 2100 (1846); Schiner, Faun. Austr. II, 47 (1864); Hendel, Abh. z. b. Ges. Wien, II, 34 (1902). *Sciomyza notata* Meigen, Syst. Bes. VI, 14 (1830); Zett. Dipt. Sc. V, 2103 (1846)) . . . . **griseola** Fallen
Head, body and legs almost entirely reddish or yellow, hypopygium yellow 7

7. Wings with yellowish costal border, the auxiliary, first and second veins yellow, remaining veins brown; body and legs reddish yellow, the front tibiæ and tarsi of ♀ dark; arista short-plumose. Eur.;* Me., N. H., Col., B. C. (*Sciomyza*) . . . . **albocostata** Fallen
All the veins brown, wings uniformly subhyaline, the crossveins sometimes clouded; body and legs usually ochraceous brown; arista plumose; robust species with large hypopygium. Eur.;* Mass.,* Queb.,* N. Dak., Mont.,* Wyom.,* Idaho,* Wash.,* Cal.* (*Sciomyza fuscipes* Mcq., Suit. Buff. II, 407 (1835); Meigen, Syst. Bes. VII, 363 (1838); Rondani, Prodr. Dipt. Ital, VII, Sciomyz, 44 (1868). *Sc. dorsata* Zetterstedt, Dipt. Sc. V, 2096 (1846); Schiner, Faun. Austr. II, 46 (1864); Becker, Act. Soc. sc. Fenn. XXVI, 56 (1900); Hendel, Abh. z. b. Ges. Wien, II, 32 (1902). *Sc. notata* Schiner, Faun. Austr. II, 48 (1864). *Sc. ruficeps* Zetterstedt, Dipt. Sc. V. 2097 (1846); Rondani, Prodr. Dipt. Ital. VII, Sciomyz, 41 (1868). *Melina spadix* Cresson, 42. *Melina fusca* Cresson, 43) . . . . **fuscipes** Macquart

8. Hind femora and tibiæ broadly paler along the center; eyes banded in life; mesopleuræ golden below, brown above; abdomen fasciate 9
Hind legs not evidently annulate; eyes uniformly colored 12

9. Face and occipital orbits with one, cheeks with two brown spots; arista rather long-plumose; scutellum sometimes yellowish; abdomen polished except on fasciæ; front legs of ♀ with femora and middle of tarsi blackish; anterior veins whitish toward base, outer part of wing largely infumated. N. H.,* N. Y., N. Car. (*Sciomyza albovaria* Coq. Proc. U. S. N. M. XXIII, 616 (1901)) . . . . **albovaria** Coquillett
Head not spotted; arista short-plumose to bare; scutellum blackish; abdomen not shining 10

10. Arista short-plumose; mesonotum vittate. Eur.;* N. Y.,* Queb.* (*Sciomyza annulipes* Zett. Dipt. Sc. V, 2113 (1846); Schiner, Faun. Austr. II, 49 (1864); Hendel, Abh. z. b. Ges. Wien, II, 26 (1902)). **annulipes** Zetterstedt
Arista bare or microscopically pubescent; mesonotal vittæ faint. (*vitalis* Cresson)..11
11. Front tarsi entirely black. Mass., Id., Cal. (Cresson, 43). var. **vitalis** Cresson
Front tarsi pale at base. D. C., Wisc. (Cresson, 44)..var. **similis** Cresson
12. Abdomen uniformly reddish, contrasting with the mostly grayish thorax; front legs dark brown, posterior legs reddish; arista nearly bare. Eur.;* Id.,* Wash.,* Or. (*Sciomyza ventralis* Fall. Dipt. Suec. Sciomyz. 14 (1820); Zetterstedt, Dipt. Sc. V. 2112 (1846); Schiner, Faun. Austr. II, 50 (1864); Becker, Act. Soc. sc. Fenn. XXVI, 9, 58 (1900); Hendel, Abh. z. b. Ges. Wien, II, 44 (1902). *Helomyza fuscimana* Roser, Wuerttemb. Corrbl. 61 (1840). *Sciomyza rufiventris* Meigen, Syst. Bes. VI, 20 (1830); Macquart, Suit. Buff. II. 408 (1835). **ventralis** Fallen
Abdomen nearly concolorous with the thorax............................13
13. Arista loosely pubescent; incisures of abdomen paler. Eur.;* N. J., Mass., Ont., Wisc., Cal. (Hough); Queb., Ill.,* Nev., Wyom.* (*Sciomyza*). **obtusa** Fallen
Arista nearly bare 14
14. Wings strongly infumated; blackish species measuring about 3 mm. with dark brown legs, the front pair blackish except the coxæ; halteres black. Pa., Ont. (Hough); Ind.* (*Sciomyza*)..............**luctifera** Loew
Wings nearly hyaline, the crossveins lightly infumated; larger species of gray-brown color with fasciate abdomen; front legs black, contrasting with their whitish coxæ and with the reddish posterior pairs; halteres yellow; antennæ black. Wyo.,* Mont.,* Id.,* Wash.,* B. C.* **palustris,** n. sp.
15. Ground-color of wings brown, filled with numerous small rounded hyaline spots; body grayish brown, marked with distinct sepia dots at base of each bristle and setula; eyes broader than deep, the head unusually wide; arista short-plumose. Tex.* (*Sciomyza*).......**guttata** Coquillett
Wings marked with a few short cross-bars; arista pubescent; eyes nearly round..16
16. About 5 bars crossing submarginal cell, discal cell with a pair of spots; fourth vein emitting appendage into second posterior cell; a small brown dot at base of each thoracic setula; a velvet black mark between antenna and eye. Tex.,* Mex. (*Sciomyza strigata* Wulp, see Malloch, Can. Ent. 1914, 324). (*Sciomyza*).......................**trabeculata** Loew
Only a preapical crossband in the submarginal cell, markings of discal cell obsolete; no appendiculate vein; thorax with alternate brown and gray vittæ; at most a brown spot beside the antennæ. Eur.;* Mass.,* Ct.,* Ont.,* Queb., N. Y.,* N. J., N. H., Pa., D. C.,* Fla., Ill.,* Ind., Wisc., Ga. (Hough); La.,* Mo., Tex.,* S. D.,* Kans. (Aldrich), Col., Wyom.,* Mont.,* Id.,* B. C.,* Wash.,* Oreg.,* Cal., Mex. (*Sciomyza*). **nana** Fallen
17. Mesopleura entirely pubescent or posteriorly setulose; 1 fronto-orbital, 0 sternopleural, 2 pteropleurals, prescutellars strong; oral angle of face acute or perpendicular in profile; arista bare, or nearly so...............18
Mesopleura bare; 2 fronto-orbitals, prescutellars vestigial; oral margin not prominent; arista pubescent to plumose; species under 5 mm............19
18. Mesopleura entirely pubescent; thickened basal portion of arista one-third arista-length; abdomen fasciate only; third antennal joint brown; grayish red species; 4 to 5 mm. Eur.; Pa., Fla., Ill.,* Wisc. (Hough). Ga.,* Tex.,* S. D. (Aldrich), Mont.,* Wash.,* Cal.* (*Sciomyza grisescens* Meigen, Syst. Bes. VI, 20 (1830); Macquart, Suit. Buff.

II, 408 (1835); Becker, Zts. Hym. Dipt. II, 253 (1902); Hendel, Abh. z. b. Ges. Wien, II, 66 (1902). *Sc. brevipes* Loew, N. Beitr. IV, 54 (1856). *Sc. humilis* Loew; Hendel, Wien ent. Ztg. XX, 199 (1901). *Sc. nasuta* Zetterstedt, Dipt. Sc. V. 2114 (1846))......**grisescens** Meigen

Mesopleura with a row of setulæ along posterior margin; basal portion of the microscopically pubescent arista one-fourth the arista-length; abdomen with three interrupted brown vittæ; antennæ reddish; robust rust-red species; 6 to 7 mm. Neb., Tex.* (Cresson, 50)..**trivittata** Cresson

19. Wing cells with single rows of variable brown spots; about 4 pteropleural bristles. Eur.;* Queb., N. Y., Ill., Col. (Hough), Wyom.,* Mont.,* Id.,* Wash.* (*Sciomyza Schoenherri* Fall., Dipt. Suec. Sciom. Suppl. 2a, 13 (1826); Zetterstedt, Dipt. Sc. V. 2107 (1846); Schiner, Faun. Austr. II, 50, (1864); Rondani, Prodr, Dipt. Ital. VII, Sciom. 45 (1868); Becker, Act. Soc. sc. Fenn. XXVI, 58 (1900); Hendel, Abh. z. b. Ges. Wien, II, 70 (1902). *Sc. monilis* Meigen, Syst. Bes. VI, 17 (1830). *Pherbellia vernalis* Desvoidy, Myodaires, 696 (1830). *Graphomyzina maculata* Cresson, 48)..............................**schoenherri** Fallen

Wings nearly hyaline, not maculate; oral margin in profile forming an obtuse angle with face. Eur.; Wyom.,* Id.* (*Sciomyza brunnipes* Meigen, Syst. Bes. VII, 364 (1838); Schiner, Faun. Austr. II, 50 (1864); Hendel, Abh. z. b. Ges. Wien, II, 71 (1902); Becker, Zts. Hym. Dipt. II, 253 (1902). *Sc. coxata* Zetterstedt, Ins. Lapp. 739 (1838). *Sc. pusilla* Zetterstedt, Ins. Lapp. 739 (1838), Dipt. Sc. V, 2115 (1846)). **brunnipes** Meigen

Melina palustris new species.

Length, 4–5 mm. Dark colored species with black front legs, vittate thorax and fasciate abdomen. Front luteous, parafrontal stripes and median triangle gray, reaching half way down the front; face and cheeks pale yellowish, a brown or black orbital spot next the antennæ, occiput black, gray dusted, the cervical spot indistinct; antennæ quite blackish, the arista black, appearing bare under ordinary magnification, two and a half times the length of the third joint; palpi yellowish. Thorax black in ground color, thickly dusted, gray above and faintly vittate, apex of scutellum reddish, a strong brown-dusted subalar stripe and a weaker stripe along the sternopleural suture, metapleural callosity velvety dark brown, pectus whitish pruinose, balance of pleuræ silvery gray; mesopleura entirely bare, pteropleura with a few hairs and two or three bristles anteriorly, sternopleura with fine bristles above. Abdomen blackish, the apices of the sclerites yellow, hypopygium blackish with more or less reddish tinge. Front coxæ white, contrasting with remainder of legs, front femora stout and setose, knees narrowly brownish; posterior legs brown, hind femora with about four setæ above. Halteres and calypteres pale yellow. Wings hyaline, anterior veins brownish, posterior veins blackish, crossveins scarcely at all infumated, sections of fourth vein proportioned 1 : 0.7 : 1, anal vein slightly more than half the underside of the discal cell.

Over one hundred specimens. Type from Lake Chatcolet, Idaho,* August, 1915. Paratypes, all collected by the author, from Yellowstone Park, Wyoming,* Three-Forks, Montana;* Priest Lake, Moscow and Lake Waha, Idaho;* Pullman and Dungeness, Washington,* and Nelson, British Columbia.*

Hemitelopteryx Cresson.

Hemitelopteryx Cresson, Trans. Am. Ent. Soc. XLVI, 51 (1920).
Heteropteryx Hendel (not Gray, 1835), Abh. z. b. Ges. Wien, II. 81 (1902); Cresson, 30 (table), 87 (list).

Head and mouth-parts black, antennæ yellow, front velvety, except the shining median stripe; thorax yellowish, with 2 broad stripes and anterior margin black; abdomen black except basal angles; legs mostly yellow, front coxæ silvery white, front tibiæ and tarsi black, except apical joints; wings blackish; 3.5 mm. N. H., Mass. (Cresson, 51). **johnsoni** Cresson

Antichæta Haliday.

Antichæta Haliday, Ann. Nat. Hist. II, 187 (1839); Hendel, Abh. z. b. Ges. Wien, II, 78 (1902).

Reddish yellow species, at most the front legs piceous; 2 fronto-orbitals.... 2
Head, thorax and abdomen black; 1 fronto-orbital; antennæ yellow, palpi black, arista heavily pubescent; sides of front velvety black; upper pleuræ shining; front coxæ white-pruinose; first vein ending beyond anterior crossvein. Wisc.*.......................... **melanosoma,** n. sp.

2. Palpi and third antennal joint black, thorax shining, the notum centrally pollinose except for 2 brown vittæ, upper pleuræ shining; more or less of front femora and tibiæ and all tarsi brown, front coxæ white; abdomen brown, ♂ genitalia reddish. Eur., Mass. (Loew coll.) (*Sciomyza analis* Meigen, Syst. Bes. VI, 15 (1830); Zetterstedt, Dipt. Sc. V. 2104 (1846). *Antichæta analis* Hendel, Abh. z. b. Ges. Wien, II. 79 (1902). *Tetanocera vittata* Haliday, Ent. Mag. I. 168 (1833). *Sciomyza vittata* Rondani, Prodr, Dipt. Ital. VII, Sciom. 43 (1868).........**analis,** Meigen
Palpi and antennæ yellowish; pleuræ more or less pollinose above........ 3

3. Dark ferruginous, thorax heavily pollinose, trivittate with black; front coxæ and posterior legs yellowish, remainder of front legs piceous; eyes deeper than long; 6 mm. Mont.*................**robiginosa,** n. sp.
Testaceous, notum not vittate; legs yellowish; eyes longer than deep; 5 mm. Mont.*..**testacea** n. sp.

Antichæta robiginosa new species.

Female—Length, 6 mm. Ferruginous; head testaceous, face and cheeks yellow and overlaid with white pruinosity, a bigeminal silvery white cervical spot on cinereous ground; middle frontal stripe shining, with parallel sides, about one-fifth the width of the front and attaining the suture; front slightly wider than long, a little narrowed anteriorly, the triangular lunule nearly hidden, two fronto-orbitals; eyes large, rounded, face receding at an angle of ninety degrees to the front, cheeks about one-third the diameter of the eye; antennæ ferruginous, second joint short, obconic, third joint ovoid, one-half longer than deep, with a slight infuscation above, arista black, finely plumose, but one-half longer than the third joint of the antennæ; palpi long, testaceous, black-setose. Mesonotum centrally blackish overlaid with gray pollen, trisected by two narrow opaque stripes of golden brown pollen, a stripe of whitish yellow pollen above notopleural suture; upper pleuræ rusty, lower white-pruinose, the ground color of the sternopleuræ largely black; thoracic bristles strong, one humeral, two notopleural, one presutural, one supra-alar, two intra-alar, two dorsocentral, no prescutellar, four scutellar, no pleural. Abdomen brown, black-setulose,

fifth tergite broadly emarginate and apically fringed with three bristles on each side. Front coxæ testaceous, but silvery pollinose, remainder of front legs piceous, the tarsi black, posterior legs including tarsi testaceous, front femora with five extensor bristles, front tibiæ with one preapical, two or three anterior bristles on middle femora, four extensor and a few short irregular bristles on hind femora, the two preapical bristles of hind tibiæ large. Halteres and calypteres brownish yellow. Wings uniformly infumated, a little stronger along the costa and besides the posterior crossvein; veins dark brown, first vein ending a little before the anterior crossvein, posterior crossvein straight, costal sections proportioned 1 : 1 : 3 : 1.2 : 0.7.

One specimen. Three Forks, Montana,* August 1, 1918.

Antichæta testacea new species.

Male—Length 5.2 mm. Occiput yellow, cervical spot brown, front luteous, periorbits subshining, extending half way to suture, middle stripe with parallel sides, complete, face, cheeks and lower occiput pale, profile very slightly concave and receding, cheeks one-third the eye-height, eyes horizontally oval, two fronto-orbitals; antennæ reddish, first joint minute, second bowl-shaped, shorter than deep and one-third as long as the oval third joint, arista black except its basal joint, its hairs moderately long and loose. Thorax entirely testaceous, not heavily dusted; genitalia large, yellow. Legs yellow, last tarsal joint darkened, front femora with about six bristles above and hind femora with about three above and eight below; middle femora with two small bristles in front near center. Halteres yellow. Wings hyaline, veins thin, yellowish, apically and crossveins darkened, posterior crossvein straight and perpendicular to fifth vein.

Holotype. Collected by A. D. Hastings, June 11, 1904, in Gallatin County, Montana.*

Antichæta melanosoma new species.

Female—Length, 4.5 mm. Body black, legs mostly yellow. Front wider than long, quadrate, middle stripe shining, parallel-sided, attaining suture, as broad as each of the opaque side stripes, periorbits shining, only one fronto-orbital; lower orbits pruinose and yellowish, center of face triangularly black, cheeks about one-fifth eye-height, lower occiput brown, upper shining black, with bigeminal silvery spot; mouthparts black; antennæ yellow, second joint shorter than deep, third joint oblong-oval, one-third longer than deep and half as long as arista, the base of the bushy black arista stout. Notum subshining, lower pleuræ pruinose, chætotaxy as in *A. robiginosa*, upper surface of abdomen shining. Legs, including coxæ, yellow; front coxæ with silvery sheen, the front legs black beyond three-fifths of the femur, two preapical bristles on hind tibia. Halteres, calypteres and root of wing yellow, wings hyaline, veins brown, not infumated, costal sections proportioned 0.8 : 1 : 1.2 : 0.8 : 0.5, anterior crossvein at middle of discal cell.

One specimen. Polk County, Wisconsin, July, collected by Professor C. F. Baker and transmitted by Dr. Aldrich.

Renocera Hendel.

Renocera Hendel, Verh. z. b. Ges. Wien, L. 333 (1900); Abh. z. b. Ges. Wien, II, 74 (1902). Cresson, 51.

Two fronto-orbitals; mesonotum opaque, vittæ distinct; cheeks nearly equal to eye; no humeral, prescutellar or presutural bristles, 1 dorsocentral; front tarsi black 2

One fronto-orbital; mesonotum subopaque, vittæ faint; cheeks narrower; base of tarsi light colored 3

2. Third antennal joint quadrate, scarcely one-half longer than deep; uniformly ochraceous; posterior crossvein inflexed. Mont.* **quadrilineata,** n. sp.

Third antennal joint broadly rounded, nearly twice as long as deep; abdomen with brown median vitta; posterior crossvein nearly perpendicular to fourth vein. Me., B. C .... **johnsoni** Cresson

3. Arista very densely plumose to tip; third antennal joint tapering to the rounded apex, slightly concave above. N. H., N. Y., Pa. (*Sciomyza*). **longipes** Loew

Arista loosely plumose or pubescent; third antennal joint rounded oblong ... 4

4. Arista very short pubescent; cheeks one-third the eye-height; periorbital shining stripe undeveloped; femoral and abdominal bristles present. N. Y. (*Chætomacera brevis* Cresson, 58) .... **brevis** Cresson

Arista short plumose; periorbital stripes shining; abdominal bristles weak 5

5. Apical 2 tarsal joints black; notum not vittate, sparsely pruinose medially; cheeks one-fourth the eye-height; anterior margin of front shining; femoral bristles weak. Me., N. H. (Cresson, 54) .... **amanda** Cresson

Last tarsal joint black; notum quadrivittate, scarcely shining; cheeks one-half the eye-height; anterior margin of front dull; femoral bristles present. Wash.* .... **cyathiformis,** n. sp.

Renocera cyathiformis new species.

Male—Length, 6 mm. Ochraceous, frontal stripes, face, cheeks, antennæ, palpi, halteres and legs yellow. Interfrontal stripe narrow and attenuated anteriorly, reaching the luteous opaque frontal margin, orbital stripes golden pollinose, reaching half way down the front, sides of front gently arching so as to constrict the front at the antennæ to two-thirds its width at the ocelli, anterior fronto-orbital vestigial; second joint of antennæ very short, bowl-shaped, much deeper than long, with numerous fine setulæ, third joint oblong oval, one-half longer than deep, the arista black, with short and rather sparse hairs; cheeks half the width of the circular eyes; palpi yellow. Thorax as in *Tetanocera*, quadrivittate, dusted, scarcely shining, one humeral, two notopleural, one presutural, one supra-alar, one intra-alar, two dorsocentral, one prescutellar, four scutellar, no propleural or other pleural bristles, sternopleuræ alone sparsely hairy. Abdomen without strong bristles, base of end-paramera of hypopygium thin and circular, terminal portion short. Middle femora with one anterior bristle; hind femora with two bristles above and about four below in the anterior row, in addition to the many flexor setæ, which are less pronounced than in species of *Tetanocera;* last tarsal joint black. Wings with strong and uniform yellow tinge, anterior veins yellow, posterior veins brown, costal region not clouded, crossveins lightly infumated, posterior crossvein straight

and transverse, sections of costa proportioned 1 : 1 : 1.5 : 1 : 0.6, of fourth vein, 1.3 : 1 : 1.4, third vein gently curved, ending at wing-tip, parallel with fourth vein, anal vein reaching margin, as long as last section of fourth vein.

One specimen. Mount Constitution, Orcas Island, Washington,* August 7, 1909.

Renocera quadrilineata new species.

Female—Length, 5 mm. Light ochraceous; front one-third broader than long, scarcely tapering anteriorly, the impressed shining middle stripe occupying one-sixth of the front, parallel-sided and attaining the suture, sides of front anteriorly yellow, two rather small fronto-orbitals; face and cheeks almost white and satiny, the cheeks nearly as wide as the circular eye; antennæ short, reddish yellow, the topmost setula of the small second joint strong, third joint quadrate-oval, one-half longer than deep, the black arista nearly twice the length of the third joint, with short sparse fine plumosity; palpi yellow, with very fine sparse black hairs. Thorax prettily marked with four chocolate brown stripes, the middle pair complete and expanding before the scutellum, the outer pair shortened in front and interrupted just behind the cross-suture, notal setulæ rather sparse, black and unusually distinct, chætotaxy reduced to two notopleural, one supra-alar, two intra-alar, one dorsocentral and four scutellar bristles; a light brown stripe along upper pleuræ, lower pleuræ pale ochraceous, sternopleuræ with a few fine setulæ. Legs yellowish, front tarsi black, about five small bristles above and eight short setæ below on front femora, middle femora with one anterior bristle, hind femora without bristles, but with a double row of stout spines beneath along the apical half, each row containing about ten; tibial bristles small. Halteres and calypteres yellow. Wings with strong yellowish tinge, blackened along the crossveins, veins basally yellowish, apically black, costal sections proportioned 1.2 : 1 : 2 : 1 : 0.6, three sections of fourth vein subequal, posterior crossvein straight, third vein gently curved, ending at wing-tip, anal vein strong.

One specimen. Three Forks, Montana,* August 1, 1918.

Poecilographa Melander.

Pœcilographa Melander, Psyche, XX, 205 (1913.)
Pœcilomyia Melander (not Hendel, Richardiinæ), Psyche, XX, 58 (1913).

Yellow, the broad convex shining interfrontalia blackish except medially, bristles of head and thorax arising from conspicuous brown spots, six pleural brown spots, three rows of light brown spots on abdomen, femora with a brown mark below toward tip; wings with a well defined brown pattern, radiating along costa and apex and forming hyaline round spots elsewhere. 4 mm. Me., N. Y., Can., N. J., Pa., Ill., Wisc.,* Col. (*Sapromyza*) .... **decora** Loew

Dictyomyia Cresson.

Dictyomyia Cresson, Trans. Am. Ent. Soc. XLVI, 82 (1920).

Brown, lower frontal orbits velvety black, a similar orbital spot below antennæ, both sets irregularly margined with white pruinosity, notum and abdomen with numerous darker dots; legs mostly testaceous; wings with blackish costal margin, roughly with two rows of spots in marginal cell, four in submarginal, three in first posterior, other cells more irregular; 6 mm. Me., Queb.,* Wyom. (Hough). (*Tetanocera*)........**ambigua** Loew

Euthycera Latreille.

Euthycera Latreille Cuvier, Regn. Anim. V, 529 (1829).
Lunigera Hendel, Verh. z. b. Ges. Wien. L. 344 (1900).

Yellowish, face silky white, lunule and 2 orbital spots black, notum with small brown setigerous spots, scutellum blackish, with velvet black margin and apical white dot; third antennal joint rounded triangular, slightly shorter than the quadrate swollen second joint; wing markings variable, the diluted spots in marginal cell irregular and numerous; 5 to 8 mm. N. H., N. Y., Queb.,* Ont., Pa.,* N. J., Md., Va., Car., Mid. States, Ind.,* Ill., Wisc.,* Tenn., Nebr. (*Tetanocera flavescens* Loew, 1847, not Desvoidy, 1830, not even a valid variety. *E. uniformis* Cresson, 74. *Tetanocera*)..**arcuata** Loew

Similar; second antennal joint shorter than third; the diluted spots of marginal cell quadrate and regular, those of submarginal and first posterior cells rounded. Me., N. H., N. Car. (Cresson, 74)............**borealis** Cresson

Trypetoptera Hendel.

Trypetoptera Hendel, Verh. z. b. Ges. Wien, L. 352 (1900).

Reddish yellow, face pale yellow, greatly receding, a brown spot beside antennæ, legs yellow, notum not spotted; second antennal joint short, nearly square, third joint short, bluntly triangular; costal border blackish, reticulations rather close and guttated, about six clear dots before second vein which scarcely reach the costa; anterior crossvein before middle of discal cell; 7 mm. Queb., Vt., N. Y., N. J.,* Pa.,* Md., Va., Mid. States, Ill.,* Ind.,* Col., Ut., N. Mex., Wyom.* (*Tetanocera pallida* Loew). (*Tetanocera*)....................................**canadensis** Macquart

Hoplodictya Cresson.

Hoplodictya Cresson, Trans. Am. Ent. Soc. XLVI. 67 (1920).

Legs more or less marked with brown; third antennal joint scimiter-shaped; wing--pattern dark brown, posterior crossvein gently arched; metapleural callosity black; posterior processes of hypopygium small and more or less triangular.. 2

Legs yellow except the dark tips of the tarsi; third antennal joint with rounded tip; wing-pattern flavous, the pale spots weakly defined, posterior crossvein gently sinuous; metapleural callosity brown; posterior processes of hypopygium long, paramera large, compressed, reniform; 7 mm. Mass.,* N. Y.,* Ga. (*Tetanocera*)......**setosa** Coquillett

2. In general 4 square spots in marginal cell in addition to other smaller spots, anterior crossvein before middle of discal cell; all femora with 3 incomplete dark rings; third antennal joint pointed; 4-5 mm. Cuba, Md., Fla., La.,* Tex.,* Nev., Cal. (*Tetanocera*).......**spinicornis** Loew

In general 5 square spots in marginal cell beyond end of first vein, anterior crossvein at middle of discal cell; posterior femora with a single dark spot underneath just beyond middle, front femora entirely yellow; third antennal joint bluntly pointed; 5-6 mm. Bermuda.* (*Tetanocera kincaidi* Johns., Ann. Ent. Soc. Am. VI, 449, 1913).......**kincaidi** Johnson

Dictya Meigen.

Dictya Meigen, Illig. Mag. II, 277 (1803), not Fabricius, Syst. Antl. 325 (1805), and not *Dyctia* Desvoidy.
Monochætophora Hendel, Verh. z. b. Ges. Wien. L. 335 (1900); Cresson, 68.

Meigen founded his genus *Dictya* on specimens of *umbrarum* Linn., but unfortunately credited the species to Fabricius instead of Linnæus. As *umbrarum* Fabr. is a different insect, belonging to the ortalid genus *Platystoma*, Cresson would make *Dictya* a synonym of *Platystoma*, and revive for the species *umbrarum* Linnæus Hendel's genus *Monochætophora*, abandoned in the Catalog of Palæarctic Diptera. Such a course carries the technical letter of nomenclatorial law unnecessarily far, for it is as difficult to conceive how the sciomyzid genus *Dictya* can be converted into an ortalid as for the proverbial leopard to change its spots.

Brownish, body and even femora with abundant dark setigerous spots, face yellowish, with central black dot, tip of front tibiæ and all femora with blackish marks; wings dark, with numerous small rounded hyaline spots; arista loosely plumose with black; front without shining stripes; 6 mm. Eur., Mass.,* N. H., Ct.,* Queb., N. Y.,* Pa., N. J., Md., D. C.,* Va., N. Car., Fla., Ga., Ia., Ind.,* Ill.,* Wisc., Ga., La., Tex.,* Kans.,* Dak., Neb., Man., Nev., Ariz., Col., Id.,* Wash.,* Or.,* Cal.,* Mex. (*Tetanocera pictipes* Loew). (*Tetanocera*)........................**umbrarum** Linnæus

Elgiva Meigen.

Elgiva Meigen, Syst. Bes. VII, 366 (1838).
Chione Desvoidy (not Megerle, 1811, Mollusca), Myodaires, 679 (1830).
Ilione Haliday, Westwood's Introd. Classif. Ins. 146 (1840).

Reddish yellow, notum lightly cinereous, with two approximate median and one lateral vittæ; face and arista white; wings whitish, costa brownish, submarginal cell hyaline, the crossveins and a longitudinal stripe behind the third vein gray, fourth vein with one or two weak spots between the crossveins. Eur.,* Me. (Boston Soc. Nat. Hist., Johnson, in litt.) (*Tetanocera lineata* Fall., not Day, Dipt. Suec. Sciom. 11 (1820); Meigen. Syst. Bes. VI. 43 (1830), VII. 366 (1838); Loew, Dipt. Beitr. I. 46 (1845); Zetterstedt, Dipt. Sc. V. 2114 (1846); Walker, Ins. Brit. II, 167 (1853). *Ilione lineata* Haliday, Westw. Introd. Classif. Ins. 146 (1840). *Elgiva lineata* Schiner, Faun. Austr. II, 63 (1864))..................**lineata** Fallen

Hedroneura Hendel.

Hedroneura Hendel, Wien. ent. Ztg. XXI, 265 (1902).

Ferruginous, face and cheeks pale yellow, silky, front wider than long, two orbital spots; antennæ reddish, second joint longer than third, the last bluntly triangular, arista white with yellow base; hind femora irregularly spinose beneath; wings yellowish in front, lightly brownish behind, with blackish spots below end of second vein, on anterior crossvein and at front end of posterior crossvein, irregular clouds also in apical cells; 7 mm. Eur.; Ct., Ont., N. Y., Ill., Wisc., Col., Wyo.,* Mont.,* Id.,* Nev., Wash.,* Or., B. C., (Cole). *Musca rufa* Panzer, F. Germ. 54 (1798). *Tetanocera rufa* Loew, Dipt. Beitr. 1, 42 (1845); Zetterstedt, Dipt. Sc. V. 2141 (1846); Schiner, Faun. Austr. II, 63 (1864); Rondani, Prodr. Dipt. Ital. VII, Sciom. 15 (1868). *T. cucularia* Fabricius, Sp. Ins. II, 449 (1781). *T. lineata* Day, not Fallen. *T. Sundewalli* Fries, Monogr. Tanypez. Suec. 17 (1823)..**rufa** Panzer

Limnia Desvoidy.

Limnia Desvoidy, Myod. 684 (1830).
Oregocera Rondani, Prodr. Dipt. Ital. I. 106 (1856), VII, Sciom. 23 (1868).

The brown costal margin distinctly interrupted by clear spots; eyes round; arista loosely plumose, third antennal joint but slightly excised above. (*Boscii* Desvoidy) 2

The uninterrupted brown costal border attaining apex of the wings; eyes horizontally oval; arista closely plumose to tip, third antennal joint distinctly excised above 3

2. Brown spots of wings paired so as to form transverse double bands, interspaces yellow. Me., Mass.,* Ct., Ont., Queb., N. Y., Pa., N. J., Md., Va., N. Car., Mid. States, Ill.,* Wisc.,* Col., Mont. (*T. combinata* Loew). (*Tetanocera*) .... **Boscii** Desvoidy, s. str.

Wing reticulation uniform, not forming cross-bands, interspaces hyaline. Me., N. H., Queb., Ont.,* N. Y., N. J., Mid. States, Mont.,* Wash.* (*T. inopa* Adams). (*Tetanocera*) .... **Boscii** var. **sparsa** Loew

3. Robust species, 7 to 8 mm. in length; second antennal joint much longer than third and strongly bristly above. Id.,* Wash.,* Or.,* Cal. (*Tetanocera*) .... **pubescens** Day

Length 4 to 7 mm.; second antennal joint not much longer than third and not remarkably setose above, usually only bisetose 4

4. Second antennal joint with distinct dark spot, third joint short and blunt; frontal bristles weak; costal margin dark, with small round spots in marginal and submarginal cells; scutellum yellow. Md. (Cresson, 78) .... **shannoni** Cresson

Antennæ not maculate, third joint more acute; frontal bristles strong; scutellum often darker 5

5. Posterior crossvein nearly straight and perpendicular; prescutellar bristles vestigial or wanting. (*costalis* Loew) 6

Posterior crossvein distinctly sinuous; prescutellar bristles more or less developed 8

6. Scutellum uniformly yellow, contrasting with the mesonotum, notal vittæ faint; submarginal cell with elongate dark spots along the second vein, the median streaks almost obliterated. N. H., N. Y., Md., Ill. var. **costalis** Loew, s. str.

Scutellum not contrasting with mesonotum; dark spots of submarginal cell usually short, median streaks usually evident 7

7. Brown of costal margin continuing unbroken to or beyond fourth vein; mesonotal vittæ strong, distinct brown vittæ present between the narrow median yellowish stripe and the lateral gray vittæ; hypopygial paramera square and bare, with prong at middle of apical edge. Mont.,* Id.,* Wash.* .... **costalis** var. **vittata**, n. var.

Brown of costal margin stopping at third vein; mesonotal vittæ faint. Avon, Id.,* 26 July, 1912 .... **costalis**, var. **brevicostalis**, n. var.

8. Notal setulæ abundant, about 4 irregular rows on the central vitta; cheeks less than half the eye-height; pubescence of arista longer and more open; front wider than long 9

Notal setulæ sparse, about 2 rows on the central stripe; cheeks more than half the eye-height; pubescence of arista short and close, almost appressed; sides of interfrontal stripe parallel; some pale spots touching second vein, about 14 pale spots in first posterior cell; dark spot at posterior fronto-orbital weak; lower pleuræ with yellow tinge. (*saratogensis* Fitch) 11

9. Wings almost uniformly brown, the costal border and faint spottings near the veins darker; vallar and pleural setulæ weak; flexor spines of hind femora ♂ moderately strong; tibiæ and base of tarsi ♂ light brown; both fronto-orbitals arising from black spots. Ga.* .**georgiæ,** n. sp.

   Wings with definite hyaline markings, about 18 clear spots in first posterior cell; vallar and pleural setulæ relatively strong; flexor spines of hind femora ♂ well developed; apex of front tibiæ brown ♂, or black ♀; front tarsi proximally brown ♂ or entirely black ♀. (*louisianæ*, n. sp)..10

10. Arista heavily plumose; interfrontal stripe ♀ widest between the anterior fronto-orbitals. La.*..................................**louisianæ,** s. str.

    Arista short-plumose; interfrontal stripe relatively narrow and nearly parallel-sided. D. C.,* Ind.*....**louisianæ,** var. **septentrionalis,** n. var.

11. Underside of hind femora ♂ strongly spinose; front wider than long; wing-spots nearly hyaline. Olga, Wash.*..**saratogensis,** var.**armipes,** n.var.

    Underside of hind femora ♂ moderately or weakly spinose; front square or slightly longer than wide..12

12. Infuscation of wing evanescent basally; only tip of front tibiæ and more or less of front tarsi dark..13

    Wing-pattern intense, infuscation not evanescent basally; apical half of front tibiæ and all of front tarsi black. Cal. (Cresson, 80).
    saratogensis, var. **severa** Cresson

13. A dense double patch of black setulæ on third sternite, paramera pentagonal and nearly bare; second antennal joint not longer than deep. Ottawa*............................**saratogensis,** var. **ottawensis,** n. var.

    No patch of setulæ on third sternite; second antennal joint somewhat longer than deep. Me., Mass.,* N. H., Vt.,* Ct., N. Y.,* Ont.,* Queb.,* N. J., Pa., Md., D. C.,* Va., N. Car., Wisc., Ill.,* Ind.,* Mo., Minn., Dak., Mont.,* Sask., Wyom., Wash.,* B. C.,* Cal. (*Tetanocera*)..**saratogensis** Fitch, s. str.

Limnia georgiæ new species.

Male—Length, 5 mm. Front and occiput fulvous, face and cheeks sericeous pale yellow, three fronto-orbital black marks well developed, a cervical brown spot, anterior orbits silvery; front nearly quadrate, slightly wider than long, the middle stripe occupying a little more than one-fifth of the front, somewhat widening anteriorly; antennæ yellow, second joint quadrate, longer than the third, with two setæ above, third joint emarginate dorsally, with rounded tip, arista defective. Thorax ferruginous, two dorsal vittæ, sides of notum and lower pleuræ cinereous, metapleural callosity brown; notal setulæ strong and close, pleural setulæ weak. Abdomen piceous brown, fourth sternite with distinct patches of black spicules. Legs yellowish, tarsi apically dark, flexor spines of hind femora moderate. Knob of halteres infuscated. Wings entirely brown, becoming flavescent around the anterior crossvein, no hyaline reticulations or brown bars, costal portion darker, a few vague, slightly darker spots near the veins, sections of fourth vein equal, posterior crossvein sinuous.

Holotype: Tifton, Georgia,* June 13, 1896, received from Dr. Hough, whose manuscript name has been retained for the species.

Limnia louisianæ new species.

Male—Length, 6 mm. Head fulvous, cheeks and face sericeous white, a square cervical and three round orbital spots black; front wider than long, middle stripe occupying nearly one-fourth of the front, widest anteriorly; second joint of antennæ oblong, with two dorsal converging bristles, third joint triangular, shorter than the second, reddish at base and distally brownish, arista as long as the antennæ, loosely and long plumose. Notum ferruginous, bivittate with gray, setulæ close and evident, but lacking on the grayish lateral stripes; upper pleuræ fulvous, lower testaceous and pollinose, metapleural callus brown, pleural setulæ unusually strong, especially the vallar pair. Abdomen grayish brown. Legs yellowish, apex of tibiæ brownish, tarsi distally dark, flexor setæ of hind femora strong. Halteres tipped with brown. Wings strongly infumated along costal portion so that no hyaline areas touch the second vein, remainder of wing with numerous quadrate hyaline areas which frequently coalesce, posterior crossvein straight in front and sinuous behind; middle section of fourth vein slightly longer than the others.

Female—7 mm. Front and its middle stripe slightly broader; apex of front tibiæ and all of front tarsi black, hind femora tipped with brown.

Opelousas, Louisiana,* March, 1897, received from Dr. Hough, whose manuscript name has been retained.

Var. ***septentrionalis***, n. var. Feathering of arista shorter; interfrontal stripe nearly parallel-sided; pleural setulæ less pronounced; reticulation of wings more definite and wider spread, the paler portions with yellowish tinge, a row of square marks touching the second vein.

Male and female, Washington, D. C.,* 17 August, 1913. A male, Lafayette, Indiana,* 4 July, 1914, has narrow interfrontal stripe and lacks the black spot at the base of the posterior fronto-orbital bristle.

Limnia saratogensis Fitch.

This species is widely distributed and is either variable or is a composite of several forms. The coordinate European species *L. unguicornis* Scopoli differs as set forth below:

L. unguicornis: Elevated patches of black setulæ present on fourth and fifth sternites; paramera bluntly triangular with tumid apex; notal setulæ abundant, about four rows on middle vitta; reticulation of wings usually evanescent behind fourth vein and weak along second vein; cervical spot large and black.

L. saratogensis: Patches of setulæ scarcely or not elevated on fourth sternite and absent on fifth; paramera irregular; notal setulæ not abundant, about two rows on middle vitta; wing-pattern more or less developed in discal and third posterior cells, not weakening along second vein; cervical spot less intense.

Tetanocera Dumeril.

Chætomacera Cresson, Trans. Am. Ent. Soc., XLVI, 54 (1920).

Cresson would discard the long established and well understood *Tetanocera*, even though he has not seen the original paper of 1798, mentioned by Osten Sacken, basing his argument upon a later and apparently different edition. As little is to be gained by the overthrow of important names until every doubt has been removed, the genus name *Tetanocera* will be here retained in its accepted usage.

Wing cells with brown cross-markings in addition to clouding of the crossveins; frontal orbits polished, interfrontal stripe reaching frontal suture; hind femora with 2, rarely 3, extensor bristles.................. 2

Wings not lattice-marked, the crossveins clouded; frontal orbits usually subshining, interfrontal stripe stopping usually before the suture; hind femora with 3 or more stouter extensor bristles.................. 3

2. Interfrontal stripe slightly wider anteriorly, parafrontal stripes extending but little in front of forward bristle; spots before second vein indistinct, 5 spots in submarginal, 3 in first posterior cell, anterior part of discal cell with 1 or 2 spots, hind crossvein oblique. N. H., Mass., N. Y., Ct., N. J.,* Pa., Md., Va............................**clara** Loew

Interfrontal stripe with parallel sides, frontal stripes extending much beyond anterior fronto-orbital; about 8 distinct spots in marginal cell, 4 in first posterior, both sides of fifth vein with spots, posterior crossvein more nearly perpendicular. Me., N. H., Vt., Mass., R. I., Pa. (Hough), Queb., Ont.,* N. Y., Ill., Col.,* Wyo.*........**valida** Loew

3. Anterior margin of front shining and connected with 3 polished stripes; paramera biexplanate at tip; hind femora apically narrowly brown; wings slightly infumated, crossveins browned, posterior crossvein nearly straight; arista with long loose plumosity. Eur.,* Man. (Meigen, Syst. Bes. VI, 41, 1830; Cresson, 65).........**silvatica** Meigen

Anterior margin of front dull; paramera more or less pointed, rounded, or truncate.. 4

4. Frontal orbits almost as wide as median stripe and polished, the median stripe continuing almost to the suture; hind femora of ♂ with 3 or 4 bristles in front and with the flexor spines not dense, of ♀ with 2 such bristles; thoracic vittæ scarcely darker; third antennal joint triangular, plumosity of arista moderately close; ocelli equidistant; posterior crossvein little curved and rather perpendicular; scutellum nearly devoid of setulæ; paramera ham-shaped, the terminal part slender and uncinate. Me., Mass.,* N. H., Vt.,* N. J., Ct., N. Y., Pa., D. C., N. Car., Queb., Ont.,* Ill.,* Col., Mont*., Wash.,* B. C......**plebeia** Loew

Paraorbits only subshining, narrow... 5

5. Arista bushy-plumose, third antennal joint subtriangular, excised above, second joint with 2 or 3 long bristles above, of ♂ quadrate in outline, of ♀ somewhat longer; cervical spot distinct, with blackish center, orbito-antennal spot black or brown, interfrontal stripe widest about two-thirds its length and almost reaching suture, ocelli equidistant; hind femora ♂ with 3 or 4 dorsal bristles and below densely bristly and spinose, of ♀ with 4 or 5 dorsal and 3 anterior bristles; costal margin infumated, posterior crossvein sinuate and oblique.............. 6

Plumosity of arista relatively less dense, third antennal joint less or not at all drawn out; posterior crossvein arcuate or straight and less oblique.. 8

6. Paramera of hypopygium in outline somewhat ham-shaped, terminating in a thin strip; third antennal joint more acutely triangular; general color ochraceous, thoracic vittæ usually quite indistinct.............. 7

Paramera short, the thickened portion hourglass-shaped, with explanate and obliquely truncate end; interfrontal stripe usually not bordered by brown; third antennal joint bluntly triangular; general color ferruginous, thoracic vittæ distinct; middle tibiæ with preapical bristle. Wash.,* Id.,* Cal.*.................................**obtusifibula,** n. sp.

7. Middle femora with preapical bristle on posterior side, hind femora with 4 extensor bristles; paramera apically narrow and angulate. Mass.,* N. H., Vt., Ct., N. Y., Pa.,* N. J., Md., Va., Can., Mich. (Hough), Wis.,* Ill.,* Mo., Col. (Hough), N. Mex., Wyo.,* Mont.,* Ut., Nev., Wash.,* Or. (Cole), Cal.,* B. C.,* Alaska*, Mex. (*plumosa* Loew)..**vicina** Macquart

Middle femora lacking preapical bristle, hind femora with 3 extensor bristles; paramera apically broad and ribbon-like. Mont.,* Id.,* Wash.*...**soror,** n. sp.

8. Right underside of last hypopygial segment bearing a strong thumb-like process, basal portion of terminal paramera elongate and parallel-sided, fifth tergite ♂ subquadrate, the fourth sternite with two apical dense patches of black spinules; third antennal joint ovoid, the arista loosely plumose; interfrontal stripe narrow, stopping at opaque border of frontal suture, and not bordered with brown, no antennal or cervical dark spots; posterior ocelli approximate; costal border not dark. Mont.,* Wyom.,* Wash.*..............................**papillifera,** n. sp.

Hypopygium symmetrically globose, fifth tergite ♂ laterally rounded, the fourth sternite with less evident patches of setulæ; interfrontal stripe encroaching on opaque frontal margin.............................. 9

9. Upper side of third antennal joint distinctly excised, arista moderately plumose; usually a trace of the antennal-orbital spot, cervical spot with brown center; ocelli usually equidistant; hind femora ♀ usually with 3 bristles above and 3 in lower anterior row; costal margin scarcely clouded.. 10

Third antennal joint ovoid, but slightly flattened above; posterior ocelli usually approximate; no posterior preapical bristle on middle femora, hind femora of known females with 1 or 2 bristles beneath on anterior edge..11

10. Paramera short, broad and thin, irregularly rhomboidal, the apical portion semicircular; a strong preapical bristle on posterior side of middle femora; posterior crossvein arcuate. N. H., Ont.,* Queb.,* N. Y., Ill.,* Wisc.,* Col., Wyo.,* Mont.,* Wash.,* B. C., Alaska.* **triangularis** Loew

Paramera long and slender, densely setulose along lower edge; middle femora lacking the preapical bristle; posterior crossvein nearly straight. Eur.*; Ont., N. Y. (Fallen, Dipt. Suec., Sciom. 9 (1820); Cresson, 64). **ferruginea** Fallen

11. End portion of hypopygial paramera spirally hooked, much longer than basal portion; antennal and cervical spots distinct; plumosity of arista rather short and close; thorax vittate; costa clouded, posterior crossvein straight and nearly perpendicular; 6 mm. Mont.*...**spirifera,** n. sp.

End portion of the contorted pollinose paramera expanded leaf-like and transparent; no orbital or cervical dark spots; front semitranslucent, the stripes not strongly differentiated; hairs of arista long and sparse; thorax not vittate; costa and apical veins somewhat clouded; 5 to 6.5 mm.. 12

Paramera narrowly triangular, the end and basal portions more or less merging; arista openly plumose, the hairs long; 6 to 8 mm..............13

12. Paramera constricted at middle, basal part ventrally setulose, edge of hypopygium deeply excised in front of paramera; posterior crossvein nearly straight. Eur.,* Me. (Loew, Stettin. Ent. Ztg. VIII, 199 (1847); Schiner, Faun. Austr. II. 57 (1864); Hendel, Verh. z. b. Ges. Wien, L. 337 (1900); Cresson, 59)........................**unicolor** Loew

    Paramera large, not constricted at beginning of the expanded apical part, not setulose, edge of hypopygium straight; posterior crossvein curved. Wash.*..**phyllophora,** n. sp.

13. End of paramera tapering; costal margin clouded, posterior crossvein perpendicular, fourth vein frequently with stubs. Can., Vt.,* N. H., Ct., N. Y.,* Wisc., Col., Mont.*......................**rotundicornis** Loew

    End of paramera duckbill-shaped; costa not clouded, posterior crossvein rather oblique. Wyo.,* Mont.*............................**montana** Day

    End portion of paramera suddenly constricted and blunt; costal margin distinctly clouded, posterior crossvein arched and oblique. Eur.;* N. H., Vt., Ct., N. Y., D. C. (Fabr. Sp. Ins. II, 441 (1781); Schiner, Faun. Austr. II, 53 (1864); Hendel, Verh. z. b. Ges. Wien, L. 342 (1900); Cresson, 59)..**elata** Fabricius

Tetanocera soror new species.

Length, 6 to 9 mm. Very close to *T. vicina* Macq., the general size of about seven millimeters being slightly smaller. Ochraceous, interfrontal stripe parallel-sided, bordered with brown, cervical and antennal orbital spots black; second antennal joint shorter than the acute third, arista very densely bushy. Thorax heavily pollinose, vittæ distinct, about four rows of setulæ on middle stripe. Abdomen subshining, hypopygium moderately small, paramera short, bluntly rounded triangular, not setulose, foramen large. Tarsi apically dark, front femora with six setæ above, middle femora with one anterior bristle at middle and none behind, hind femora with three dorsal and a double full series of ventral bristles and flexor setulæ. Wings lutescent basally, outer costal and apical portions infumated, crossveins bordered with black, posterior crossvein lightly sinuous.

Type: Mica, Washington,* 14 July, 1918. Thirteen paratypes, Pullman and Mount Constitution, Washington;* Avon, Idaho;* Beaver Creek, Montana,* (Hunter).

Tetanocera obtusifibula new species.

Length, 8 to 11 mm. Closely resembling *T. vicina*, the males easily recognizable by the centrally constricted tubular paramera of the hypopygium. Cervical spot dark brown bounded by yellow; interfrontal stripe reaching to or beyond the middle of the luteous sutural band, laterally bounded with brown; orbital spot at antennæ black, merging into golden at the eye; face and cheeks golden sericeous; outer side of second antennal joint one-fourth longer than deep, third joint triangular, with rounded excision above and apically rather pointed; arista very bushy plumose, with stout base. Thorax with complete median pair of rusty brown vittæ and with two interrupted lateral stripes, making six vittæ between the wings. Abdomen uniformly ferruginous yellow, paramera of hypopygium not pollinose, relatively

short and thick, somewhat constricted at the middle and apically obliquely truncate. Only apical joints of tarsi blackened, front femora with about seven bristles above, middle femora with one anterior bristle, hind femora with four or five bristles above and in male with a complete row below, in female with two or three in front below proximal to the row of about ten setæ. Wings with yellowish tinge, the apical half of costal margin slightly infumated, crossveins slightly clouded, posterior crossvein sinuous.

Thirty-seven specimens. Pullman and Mount Constitution, Washington;* Worley, Idaho;* Stanford, California.* June to September. The females are difficult to distinguish from large and vittate specimens of *T. vicina*. Although somewhat variable, the following characters will help: In *obtusifibula* the small spur of the preapical pair on the hind tibiæ is about two-thirds, instead of less than one-half, the length of the larger; the apical row of setæ of the underside of the hind femora contains about ten, instead of about eight, setæ, proximal to which are two or three or even four, instead of one or two, stout bristles, while in the posterior inferior row of the hind femora are three or rarely four relatively weak, instead of four relatively strong, bristles; the middle stripe of the front is usually narrower, typically about one-half, instead of two-thirds, as wide as long and usually the sutural luteous band is somewhat wider.

Tetanocera papillifera new species.

Male—Length, 9–10 mm. Ochraceous; resembling *vicina*, but readily distinct in structure of hypopygium. Front quadrate, dull luteous along the suture, interfrontal and parafrontal stripes shining, the former one-eighth the width of front and interrupted by the transverse luteous band; face greatly receding, silky white, the silvery occipital spot with pale brown center; second and third antennal joints subequal, the second joint expanding from the base and rather strongly setulose, third joint one-half longer than deep, with evenly rounded apex; arista black, with enlarged base, plumose with fine long and rather sparse hairs. Mesonotum marked with six narrow brown vittæ, the central pair longest, but not attaining the neck. A notopleural light brown stripe extending along the pale yellow pluræ, metapleural callosity light brown, sternopleural setulæ distinct. Abdomen subshining, setulose, fifth tergite fringed with about twelve long apical bristles, laterally nearly straight and parallel-sided, transversely narrower than the third or fourth tergites; hypopygium finely setulose, the terminal portion bearing a strong mammiform papilla on the right side at the apex, foramen large, circular; double patches of black setulæ of last sternite dense. Legs entirely yellowish, wings nearly hyaline, crossveins infumated; posterior crossvein slightly arched.

Type, Pullman, Washington; paratypes, same locality and Tacoma, Washington; Yellowstone Lake, Wyoming; Missoula, Montana. All the specimens were taken during August.

Tetanocera spirifera new species.

Male—Length 6 mm. Front yellow, orbits silvery, paraorbits scarcely shining, middle stripe depressed, narrow, extending through the luteous fascia, its nearly parallel sides bounded by brown; antennal orbital spot brown, cervical spot brown, enclosed by a silvery mark; face and cheeks sericeous white; antennæ relatively short, the second joint obconic, as long as deep and three-fifths the length of the bluntly triangular, almost quadrate, third joint, arista two-thirds longer than the last joint, its base thick, its plumosity moderately close and long. Mesonotum ochraceous, with narrow light brown acrostichal vittæ and broader lateral stripes; pleuræ pale ochraceous, with superior fulvous band as usual. Abdomen unicolorous ochraceous, hypopygium moderate, with pronounced posterior swelling before the foramen, paramera short, very slender, twisted corkscrew-like. Legs yellow, tarsi dusky, front coxæ with four bristles, front femora with four dorsal bristles, middle femora with one anterior bristle, hind femora with two dorsal and about six short bristles in each flexor row in addition to the apical pectination and proximal moderately sparse setulæ. Wings with yellowish tinge, costal margin, apex and crossveins infumated, sections of fourth vein proportioned 1 : 0.8 : 1, posterior crossvein gently curved, anal vein slightly longer than half the discal cell.

Type and female, Nigger Hills of Powell County, Montana,* July, received from Wm. M. Mann; paratype male, Gardiner, Montana,* 17 August, 1918.

Tetanocera phyllophora new species.

Male—Length, 6.5 mm. Front yellow, somewhat translucent, parafrontal stripes subshining, median stripe scarcely depressed, narrowly triangular, vanishing at the luteous sutural edge; occiput subshining yellow, no cervical dark spot; face and cheeks pale yellow, sericeous; antennæ relatively short, second joint obconic, as deep as long and three-fifths the length of the third joint, the last rounded triangular, one-third longer than deep at base, the lower edge convex, arista delicate, scarcely twice as long as the third joint, loosely plumose. Mesonotum uniformly ferruginous-yellow, not vittate; pleuræ dusted, ochraceous below the pale brownish notopleural portion. Abdomen ochraceous, foramen of hypopygium small, paramera long, curved, pollinose except on the pubescent, shining, explanate, pointed tip. Legs entirely yellow, front femora with five outstanding dorsal bristles, middle femora with one anterior bristle, hind femora with two dorsal bristles, and about five below in addition to abundant flexor setæ along the entire length. Wings with flavescent tinge, veins yellowish toward

base and brownish distally, crossveins strongly and wing-tip weakly infumated, posterior crossvein gently curved, sections of fourth vein proportioned 1 : 0.9 : 1, anal vein not exceeding half the length of the discal cell.

Holotype: Mount Constitution, Orcas Island, Washington,* 7 August, 1909. While there are two normal fronto-orbital bristles on the right side, the anterior is completely lacking on the left. Were a single fronto-orbital a normal occurrence, the shortened antennæ and the narrow tapering interfrontal stripe would be suggestive of *Renocera*. The species is closely related to *T. unicolor* Loew.

Sepedon Latreille.

Middle femora spinose beneath; wings brown or strongly infumated, third and fourth veins apically converging; length about 8 mm.......... 2

Middle femora not spinose, hind femora relatively short and stout, none of the femora black-tipped; wings grayish, third and fourth veins parallel; frontal spot black; third antennal joint blunt, arista mostly white and half again longer than the third antennal joint; length about 5 mm.......... 6

2. Second antennal joint as thick as the bluntly triangular third; thorax, abdomen and legs reddish brown; frontal spot velvety brown; halteres yellowish; hind femora not excessively long.......... 3

Second antennal joint very slender and long, arista largely dark and nearly twice the length of the third antennal joint; abdomen at least metallic blue; all femora tipped with black, hind femora slender and nearly twice as long as abdomen.......... 4

3. Third and fourth veins nearly parallel; central depression of front three times as wide as lateral depression. Me. (Hough), Mass.,* R. I., N. Y.,* Queb., Ont.,* N. J., Pa., Md., Ill.,* Ida.,* Man......**fuscipennis** Loew

Third and fourth veins slightly convergent; central depression of front less than twice as wide as lateral depression. Wyo.,* Ut., Ida.,* Wash.,* Cal. (Cresson, Ent. News, XXV, 457 (1914)...**pacifica** Cresson

4. Front broadly excavated, with weak ridges; posterior crossvein bowed outwards. D. C., Md., Va. (Cresson, 84)........**tenuicornis** Cresson

Front narrowly excavated, with prominent ridges; posterior crossvein straight.......... 5

5. Hind femora with blackish annulus beyond the middle; velvety frontal spot concolorous with shining portion of front; thorax reddish; third antennal joint acute; halteres brownish. Jam., Porto Rico, Cuba,* Mex., Tex. (*nigriventris* Wulp)..........**macropus** Walker

Hind femora not annulate but black on apical third; frontal spot black; thorax with two pronounced blue vittæ; third antennal joint with rounded apex; knob of halteres black. Haiti.*...........**cæruleus**, n. sp.

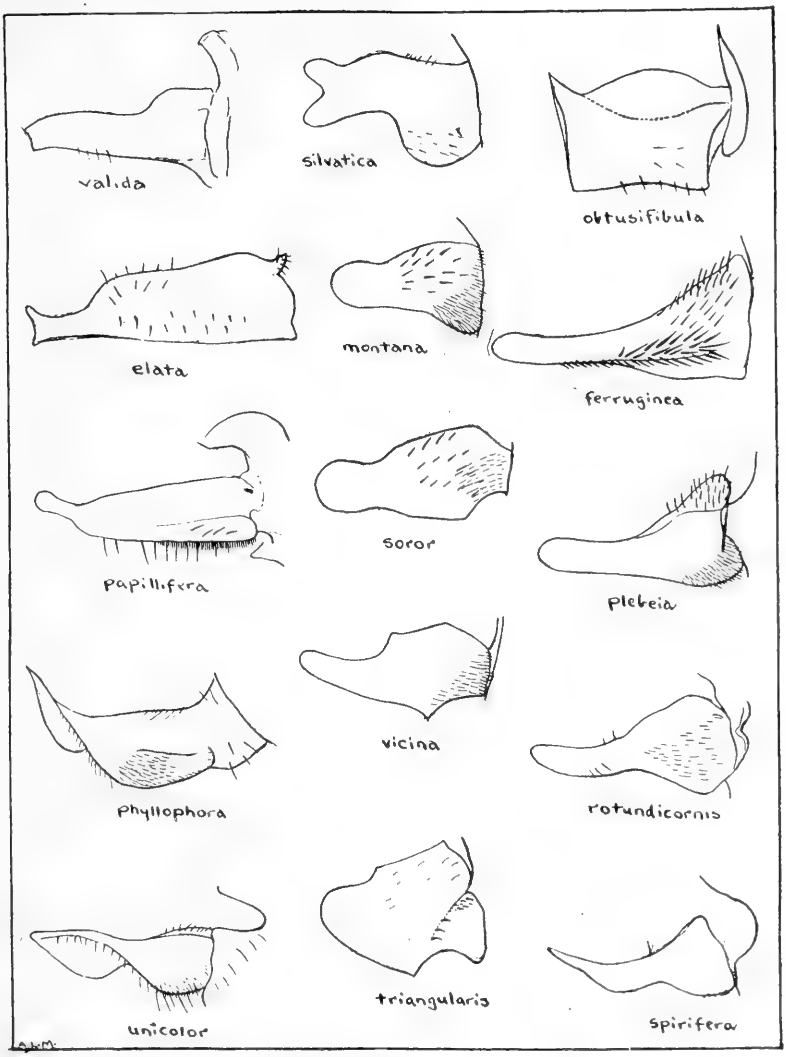
6. Underside of ♂ hind femora deeply excised and bearing 2 prongs; color generally yellowish brown; apical segments of ♀ abdomen compressed, carinate above. Mass.,* Ct., N. Y., Ont.,* Md., D. C.,* N. J., Ga., Ohio, Ill.,* Mich., S. D., Col., Tex.,* Mont.,* Wyom.,* Wash.,* Cal. **armipes** Loew

Femora of both sexes simple; color generally piceous; apical segments of ♀ arched above. Mass.,* N. H., N. Y.,* N. J., Md., D. C., Va., Ga., Mid. States, Neb., Wyo.,* Mont.,* Ida.,* Wash.,* Cal...**pusillus** Loew

Sepedon cæruleus new species.

Male—Length, 8 mm. Head yellow, a shield-shaped cervical spot and an elongate infraocular mark white-pruinose, black orbital spots at middle of front and at antennæ, upper frontal orbits dusky; antennæ black, first joint quadrate, second joint attenuated, two-thirds longer than the third, which is twice as long as deep and apically rounded, arista nearly twice the length of the third antennal joint, white on apical half and basally brown, its second joint four times as long as wide; palpi yellow, the extreme tip dusky. Mesonotum metallic blue between the complete median black vitta and the sides, scutellum medially black from a continuation of the notal vitta and laterally blue; upper pleuræ with reddish tinge, lower bluish superimposed with white pollen. Abdomen entirely dark blue with bronze tinge. Legs, including coxæ, mostly reddish yellow, femora tipped with black, the hind pair more broadly so, hind tibiæ dark, except a subapical band, tarsi dusky, front femora not spinose. Halteres with blackened knob. Wings strongly infumated, veins black, first posterior cell as wide at middle as the end of the discal cell, anal vein incomplete, sections of fourth vein equal, posterior crossvein arched, but much less oblique than in *S. fuscipennis*.

Holotype: Haiti,* received from Dr. Hough.



Left terminal valve of hypopygium of the American species of *Tetanocera.*

A. L. Melander

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ANNALS

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The Entomological Society of America

Volume XIII DECEMBER, 1920 Number 4

AN ECOLOGICAL STUDY OF HAMMOCK AND PINEY WOODS INSECTS IN FLORIDA.*

HERBERT L. DOZIER.

CONTENTS.

PART I.

PREFACE.

"No one can have been long engaged in collecting insects without having noticed the remarkable diversity in the products of different years, not only in quantity, but in kinds. Each summer seems to bring its own particular species to the front, so that if a person wishes to get a moderately correct idea of the insects of any locality, it is necessary for him not only to hunt diligently all the season, but every season for a considerable length of time; and if he has from any cause missed one, he

*A thesis (revised to date) presented to the faculty of the University of Florida in partial fulfillment of the requirement for the degree of Master of Science, June, 1917.

may be sure he has missed something which it may be years before he will again have an opportunity of securing, or securing in the same abundance." The causes of these variations are yet to a great extent an unsolved and puzzling mystery.

INTRODUCTION.

As there has been nothing published on the ecology of insects in Florida, the following study was undertaken. It is the first of its kind made in the State and to the knowledge of the writer in the Southern States.

Because of the close interrelation of insect with plant life it is essential that the investigator be acquainted with the plant life of the region studied. In this respect the writer has been greatly aided by Dr. Roland M. Harper's two interesting and instructive articles, "Florida Vegetation Types" and the "Geography and Vegetation of Northern Florida." These, although treating the flora from a purely floristic point of view and not from an ecological one, have been of much help and have been freely drawn upon.

Realizing the utter impossibility of completing a study of all the vegetation types in the time available, the writer has narrowed himself down to that of the hammocks and piney woods. The study of the hammocks has been as intensive as time allowed, while that of the piney woods has been only superficial. It is hoped that this paper may prove an incentive and an aid to some future student in a more comprehensive and complete faunal study of the region.

It represents the results of work running over a period of nearly two years (January 1, 1916, to June 1, 1917), although only half of each day during the academic year was spent on it. Observations were made and collecting done, however, during the summer.

Due to the interest of the writer in Coleoptera, collecting in this group have been more intensive than in the others.

The photographs are the original work of the author.

ACKNOWLEDGMENTS.

A study of this kind has entailed endless collecting and identifying of material.

I wish to acknowledge the assistance and supervision of Dr. H. S. Davis, under whose direction the work was done.

The help and advice of Prof. J. R. Watson, who is also carrying on ecological work, has been invaluable. He has also allowed the use of a few of his records, which are duly credited.

The bulk of the coleoptera determinations has been made by Mr. W. S. Fisher, of the U. S. National Museum, to whom I am especially indebted. Others who have determined material are as follows: W. T. Davis (Orthoptera, Cicadidæ and Odonata), Dr. Herbert Osborn (Homoptera and Tingidæ), A. A. Girault (Chalcidæ), Dr. L. O. Howard (Chalcidæ), J. J. Davis (Aphididæ and Lachnosterna), Z. P. Metcalf (Homoptera), W. S. Blatchey (Coleoptera), J. M. Aldrich (Diptera), C. T. Greene (Forest Diptera), Dr. C. H. T. Townsend (Diptera), Carl Heinrich (Micro-lepidoptera), Wm. Beutenmuller (Cynipidæ), Dr. E. P. Felt (Cecidomyidæ), Dr. A. D. Hopkins (Scolytidæ), A. B. Gahan (Hymenoptera), J. R. Watson (Thysanoptera and Macro-lepidoptera), Dr. H. T. Fernald (Sphecidæ), J. A. Hyslop (Elateridæ), Dr. E. A. Schwarz (Coleoptera), S. A. Rohwer (Hymenoptera), and Dr. Nathan A. Cobb (Nematodes).

DEFINITION AND DESCRIPTION OF HAMMOCK.

The term "hammock" is applied in Florida to the dense hardwood and cabbage-palmetto forests, as distinguished from the open pine lands and cypress swamps. The timber growth of the hammocks is most frequently deciduous or largely so, although the predominating growth may be evergreen.

The variable soil and drainage conditions give rise to a wide variation of vegetation types. The hammocks around Gainesville are of two types, high and low hammocks.

HIGH HAMMOCK.

The trees of the high hammocks are tall and straight. In some places the underbrush is sparse, but in others forms a dense entanglement. On the richest spots the trees are nearly all deciduous, the proportion of evergreens increasing with the sandiness of the soil.

The following is a list of the principal plants observed, giving both the scientific and common names. Those that are evergreens are indicated by heavy type, those that are only partially so by the specific name being in heavy type.

TREES.

Magnolia grandiflora	Magnolia.
Quercus laurifolia	Laurel oak.
Liquidambar styraciflua	Sweet gum.
Tilia pubescens	Linden or basswood.
Hicoria glabra	Hickory.
Cercis canadensis	Redbud.

Fig. 1. View in a typical mesophytic magnolia hammock.

Ostrya virginiana	Hop hornbeam.
Quercus **nigra**	Water oak.
Quercus virginiana	Live oak.
Cornus florida	Dogwood.
Persia borbonia	Red bay.
Fraxinus americana	Ash.
Carpinus caroliniana	Ironwood.
Pinus taeda	Short-leaf pine.
Ilex opaca	Holly.
Quercus marylandica	Black-jack oak.
Prunus serotina	Wild cherry.
Prunus angustifolia	Wild plum.
Crataegus spp	Red haw.

VINES.

Rhus radicans....................Poison ivy.
Vitis rotundifolia..................Bullace or Muscadine.
Gelsemium sempervirens...........Yellow jessamine.
Rubus trivialis....................Dew berry.
Bignonia crucigera.................Cross-vine.
Smilax lanceolata..................Wild smilax.

Fig. 2. Hammock that has been partly cut over and burned, showing the saw palmetto dominant on the forest floor.

SHRUBS AND HERBS.

Osmanthus americana..............Wild olive.
Ilex vomitoria.....................Yaupon.
Serenoa serrulata..................Saw-palmetto.
Tillandsia usneoides...............Spanish moss.
Phoredendron flavescens...........Mistletoe.
Arisaema triphyllum...............Jack-in-the-pulpit.
Arisaema dracontium..............Adder's tongue.
Mitchella repens..................Partridge berry.

Mosses, violets, ferns and grasses.

A large percentage of the vegetation is made up of evergreens. The rarity of fire is shown by the abundance of vines and underbrush.

High hammock soil is a very desirable one for trucking and general farming, but is very expensive to clear for cultivation.

LOW HAMMOCK.

Low hammocks are nearly always a little lower than the surrounding country, and damp, but hardly wet enough to be called swamps. In low spots in these hammocks the vegetation is often essentially the same as that of the swamps.

The trees are for the most part tall and straight, making a dense shade. Fires rarely ever occur as the humus probably never gets dry enough to burn.

The following is a list of the principal plants observed.

TREES.

Acer rubrum	Red maple.
Quercus **nigra**	Water oak.
Liquidambar styraciflua	Sweet gum.
Magnolia grandiflora	Magnolia.
Taxodium distichum	Cypress.
Quercus virginiana	Live oak.
Persea pubescens	Swamp red bay.
Fraxinus caroliniana	Ash.
Ilex opaca	Holly.
Carpinus caroliniana	Ironwood.
Quercus michauxii	Swamp Chestnut oak.
Nyssa biflora	Black gum.
Morus rubra	Mulberry.
Magnolia glauca	Sweet Bay.
Hicoria sp	Hickory.

VINES.

Smilax lanceolata	Wild smilax.
Rhus radicans	Poison Ivy.
Vitis rotundifolia	Bullace or Muscadine.
Vitis aestivalis	Wild grape.
Bignonia crucigera	Cross-vine.

SHRUBS AND HERBS.

Ilex vomitoria	Yaupon.
Serenoa serrulata	Saw-palmetto.
Aralia spinosa	Prickly ash.
Tillandsia usneoides	Spanish moss.

Violets, ferns and sedges.

The percentage of evergreens is very nearly the same as in the high hammocks. Vines and underbrush are also abundant.

DESCRIPTION OF PINEY WOODS.

There is a very small area covered by piney woods around the University in proportion to that covered by hammocks. The soil is mostly sand, with practically no humus, due to frequent fires and lack of shade. The vegetation consists mainly of long-leaf pine and the red and live oaks.

Fig. 3. Typical piney woods, showing long-leaf pine and the small scrub and red oaks.

Fire is a very important factor in the development of piney woods. Nearly every tree has its bark blackened at the base, and every prostrate log and stump is charred. The woods are fired at more or less regular intervals by man, principally for improving grazing and keeping down the underbrush. Many are set also through carelessness or by accident.

On account of its thick, fire-proof bark, the long-leaf pine does not suffer much injury from fire after it is three or four years old. Therefore, if any spot escapes burning for that period of time there is a chance for the pine to reproduce itself.

The following is a list of the principal plants observed.

Pinus palustris	Long-leaf pine.
Quercus geminata	Live oak.
Quercus falcata	Red oak.
Hicoria alba (?)	Hickory.
Quercus laurifolia	Laurel oak.
Quercus catesbaei	Forked-leaf black-jack.
Quercus **nigra**	Water oak.
Castanea alnifolia	Chinquepin.

Seventy-five per cent of the vegetation is made up of pine and red and live oaks. There is a large number of shrubs and herbs, a large proportion being Leguminosæ. About fifteen per cent of the shrubs are Ericads. At certain seasons of the year the wire-grass, *Aristida stricta*, and the broom-sedge, *Andropognon virginicus*, are very conspicuous. Mosses, lichens, and woody vines are rare, being destroyed and kept out by fire.

The soil, although naturally less fertile than the nearby hammock land, is much easier to clear and to plow. A considerable part of what was once piney woods is now under cultivation.

Location and Physical Characteristics.

General Account of the Gainesville Region.

Gainesville is located in the peninsular portion of Florida about midway between the extremities of the State, lying in about latitude 29° 40' and longitude 82° 20'. It is located in what Harper ('14) terms the Middle Florida Hammock belt.

The soil of the region as a whole is a sandy loam, containing very little humus. There is more or less clay, ordinarily at

a depth of from six to ten feet. Clay or limestone underlies the region studied, with outcroppings of limestone frequently showing on the surface. Where the action of water has dissolved out the lime, numerous subterranean passages have been formed. These cave in, forming the so-called "sinks." Sinks often occur in long chains. In those sinks, which seldom go dry, there is an accumulation of muck and peat on the bottom, formed largely from the abundant aquatic vegetation. The

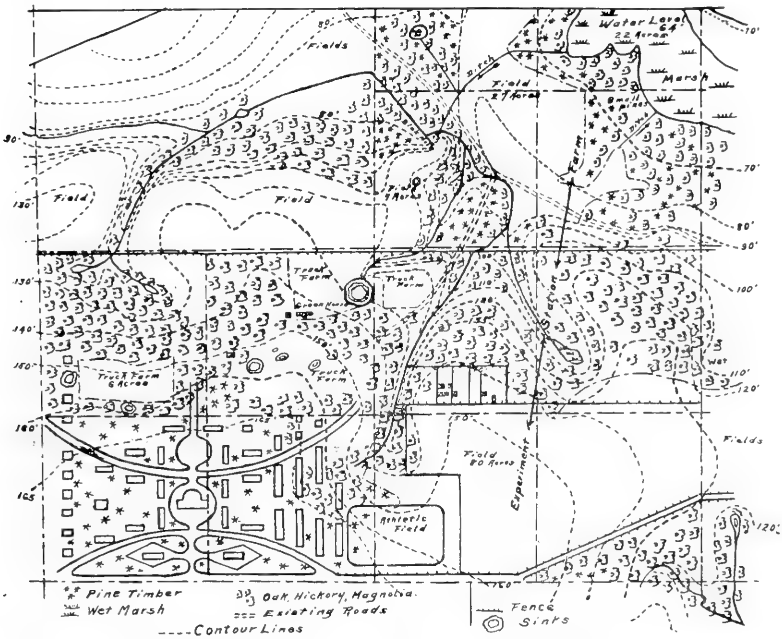

Fig. 4. Map of the University of Florida vicinity, showing the types of vegetation.

surface is not infrequently entirely covered with duckweed (Lemna). Not all of these depressions, however, contain water, many being dry the year round.

DESCRIPTION OF THE TERRITORY COVERED.

The University of Florida occupies a tract of six hundred and four acres, situated in the southwestern extremity of Gainesville. Ninety acres of this tract are devoted to the campus, drill grounds, and athletic fields. This was originally piney woods and scattered over the campus are still to be seen numbers of tall long-leaf pines.

Starting at the Experiment Station building and following the road south, we find on our left a small tract of piney woods just before we come to "Gator Sink." Continuing, we find

Fig. 5. A view of Catocala Glen.

back of the barn typical magnolia hammock, which extends to a lane leading westward. A similar hammock lies in the northwest corner of the Horticultural grounds. Continuing the lane westward (See map) is a clearing about 60 feet wide that

follows a telegraph line. This extends through the hammock to the wire fence marking the western boundary of the University property. Here it turns south, leading us to the edge of Lake Alice. This is a shallow lake during the rainy season only, being a marsh the rest of the year. Here we find bordering the lake low hammock, containing a lot of red maple and leading into black gum and cypress.

Fig. 6. Hogtown Creek, showing the character of the vegetation along its banks.

Originating back of the University Commons is a small stream which continues a winding passage through the hammocks in a ravine, known as Catocala Glen (Fig. 5), and crosses the road running south from the farm buildings and, uniting with another small stream, flows southward and comes to an end in a small sink in the ground near the target range. This stream has a very disagreeable odor, due to the sewage that empties into it.

Bounding the University property on the north is the Newberry Road. The Ocala Road bounds it on the east and south. Following the Ocala Road northward until we strike a branch of Hogtown Creek we find magnolia hammock. This branch of Hogtown Creek runs along in a winding course through hammock until it joins the east branch of Hogtown Creek. Hogtown Creek crosses the Newberry Road about a mile and a half from the University grounds. (Fig. 6).

Every year during the rainy season Hogtown Creek overflows, flooding the surrounding country and making an alluvial floodplain. Growth along its banks is at most places very rank. This is a favorite place for Geometridæ.

Just beyond the College Inn, on the right of the Newberry Road, is typical piney woods, which extends to the western boundary of the University property.

TEMPERATURE AND CLIMATE.

The following table shows the average temperature and rainfall at Gainesville, down to 1908.

Gainesville	Temperature			Growing Season	Rainfall		
	January	July	Annual		Annual	Percent June-Sep.	Percent May-Oct.
	54.9	81.4	69.3	294	51.34	54.1	66.5

The most salient features of the climate are the mild dry winters and wet summers. The rainy season begins in June and lasts until September. The copious summer rains seem to be largely responsible for the prevalence of poor sandy soils and evergreen trees in Florida, for the rain tends to leach out the clay, lime, potash, etc., leaving the plain sand. Evergreens (Harper '14) seem to be especially characteristic of soils poor in clay and potash.

There is a killing frost nearly every winter, the average date being December 11th, and occasionally a freeze. A temperature as low as 26° is common.

As a whole this is not a region of high winds. During cold weather and strong winds, insects find a haven of safety in the deep recesses of the hammocks.

ECOLOGICAL SUCCESSION.

All recent geological formations when first elevated above sea-level consist of sand dunes and hills, with swampy depressions or even lakes between them. A little east of Gainesville in what Harper ('15) calls the East Florida Flatwoods belt, we get a plant association that he calls scrub. This is the first association to take possession of the low hills.

There are two distinct ways in which hammocks originate. (1) Going from high pine land to hammock and (2) swamps and lakes to hammock.

Starting with High Pine Land we find it composed mostly of long-leaf pine with grasses and a few saw-palmettoes on the forest floor. There is very little shrubbery. After a little humus has gotten into the soil the black-jack, turkey, post and red oaks begin to come in.* This stage is known as Piney Woods.

Hickories and water oaks begin to come in and in dry situations we get the live oaks. This is the beginning of the Hammock. Now the oaks and hickories become more numerous, sweet gum enters, and the shrubbery thickens. In the last stage the magnolia becomes the dominant tree and the shrubbery becomes, in many instances, an almost impenetrable jungle.

Starting with the shallow lake, we have in the deeper water pond lilies (floating all around in the water are the recently introduced water hyacinthes). Coming near the shore we find saw-grass, rushes, and a little willow; the buttonbush is typical of such places. Cypress comes in, forming a cypress swamp. Tupelo is nearly always mixed in with the cypress. As sand is washed in and dead trees fill up the swamp, among the old cypress and tupelo and in dry situations, the red maple comes in. In turn follow the ash, water oaks, hornbeam, and sweet gums. Finally, when everything is filled up and well-drained, the magnolia and hickories begin to come in, giving us the climax magnolia-hickory-oak association.

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*It is reasonably certain that if fires were kept out of a long-leaf pine forest long enough, hardwood trees of various kinds would come in and choke out the pine (which does not thrive in shade), and thus gradually convert the pine forest into a hammock. Hammock trees require humus and are sensitive to fire, and consequently they cannot invade the pine land very fast as long as fires prevail.

If all of these various types of vegetation were to be left undisturbed by the agencies of man, such as lumbering, fires and agricultural activities, the whole country would in the end go to the climax magnolia-hickory-oak association.

The rapidity with which the climax association takes possession of the country is dependent on the kind of soil present.

CLIMAX ASSOCIATION.

(M. grandiflora) Magnolia	Magnolia (M. grandiflora)
(Hicoria glabra) Hickory	Hickory (Hicoria glabra)
(L. styraciflua) Sweet gum	Red maple (Acer rubrum)
(P. echinata) Short-leaf pine	Black gum (Nyssa spp.)
(Q. nigra) Water Oak	Cypress {(T. distichum)
(Q. falcata) Spanish oak	(T. imbricarium)}
(Q. virginiana) Live oak	Buttonbush (Cephalanthus americanum)
(P. palustris) Long-leaf pine	Bulrush (Scirpus validus)
{(Q. catesbaei)	Water hyacinth (Piaropus crassipes)
(Q. laurifolia) Scrub oaks	Bonnets (Nymphaea macrophylla)
(Q. pumila)}	Water-lily (Castalia odorata)
(P. clausa) Spruce pine	
Spruce Pine Land	Pond or Lake

Fig. 7. Showing the convergence of two types of habitats to the climax association, the magnolia-hickory-oak hammock.

PART II.

Relation of Hammock Insects To Their Environment.

I. GROUND STRATUM.

Earthworms are abundant and beneath old logs and loose bark large numbers of millepedes and centipedes are to be found. A prettily-marked lampyrid larva was observed devouring one of these millipedes. Snails and sow-bugs are also plentiful.

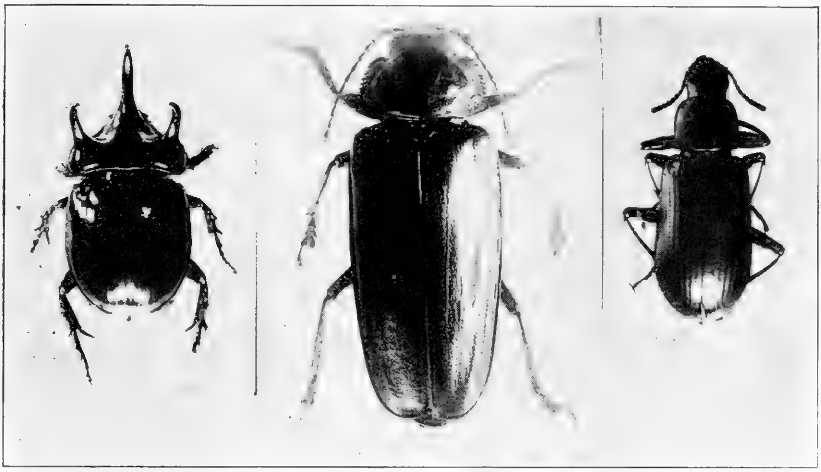

Fig. 8. *a,* Strategus antaeus, showing the long and formidable-looking horns which vary greatly in different individuals. Nat. size.
b, a wood-borer, Mallodon mellanopus. Nat. size.
c, Nyctobates barbata Knoch., which is found beneath the loose bark of decaying tree trunks. Twice nat. size.

The bark and wood of fallen trees offer a home to numerous insects (Fig. 8). When the bark has become loosened, we find practically all of the small invertebrates that are recorded from the ground. *Vespa carolina, Diaperis maculata* var. *floridana,* and often large colonies of the green stink-bug, *Nezara viridula,* hibernate beneath the loose bark. In the same habitat are also found the earwig, *Vostox brunneipennis,* and the large *wood roach, Eurycotis floridana.*

Beneath fallen logs, the tenebrionids, *Polypleurus nitidus, P. geminatus* and *Helops cisteloides,* occasionally *Strategus antaeus,* and various carabids are to be found in abundance.

The logs are inhabited by the large wood-borers *Prionus* (Fig. 9) and *Orthosoma brunneum.* The wood-eating beetle, *Passalus cornutus*, assisted by the rotten log caterpillar, *Scoleco-campa liburna*, the large ant *Campanotus fallax* var. *decipiens*, and termites soon reduce the log to a mere paper shell. Numbers of wireworms and borers live beneath the bark. Larvæ of the elaterid, *Orthostethus infuscatus* (Fig. 10) are characteristic of

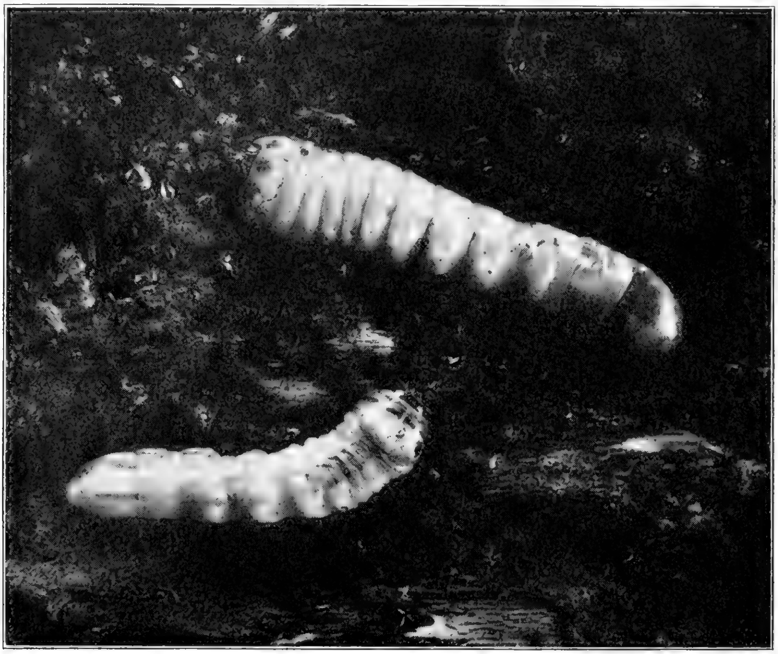

Fig. 9. Prionid larvæ in sweet gum log. Nat. size.

well-decayed logs. Numerous beetles, such as *Tritoma festiva, T. thoracica* and *Boletotherus bifurcus*, feed on fungi. A large slug is also common.

In dry protected spots beneath trees may be found the funnel-shaped pits of the ant-lions and occasionally one finds the burrows of a tiger-beetle.

Larvæ of *Lachnosterna* beetles, *Trichius piger* and *T. delta* inhabit old oak stumps. (Fig. 9).

II. FIELD AND SHRUB STRATUM.

The young trees go to make up a considerable portion of this stratum and together with the numerous shrubs and herbs support large numbers of insects. The tree- and leaf-hoppers are particularly abundant.

Lepidopterous larvæ are also very abundant, some tying and rolling leaves, others mining them. The larvæ of *Gelechia cercerisella*, a particularly interesting species, fold the leaves of young redbud. The leaves of the basswood are often made unsightly by the work of *Pantagrapha limnata*. (Fig. 11).

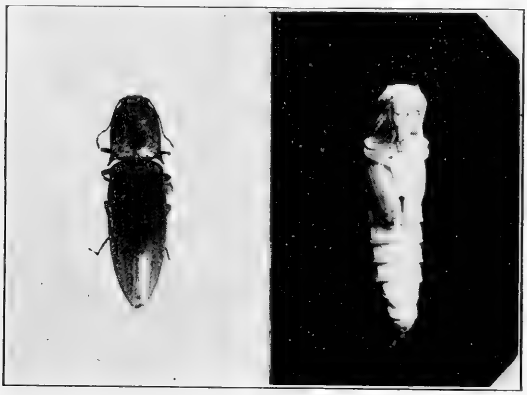

Fig. 10. The adult and pupa of the wireworm, *Orthostethus infuscatus*. Nat. size.

The pretty and strikingly-colored syrphid, *Milesia virginiensis*, is found buzzing around fallen logs and is taken occasionally at flowers. Many beetles, as *Coptocycla clavata* and members of the genus *Lema* are found feeding on the low herbage. (Fig. 12).

Grasshoppers are found in this stratum, but are not particularly numerous. The locustids greatly outnumber the acridiids. In low marshy places at the edge of hammocks are found the grouse-locusts, *Tettigidea lateralis lateralis* and *Neotettix coarctatus*.

The blue chrysomelid, *Porphyraspis cyanea*, (Fig. 13), is typical of the saw-palmetto upon which host alone it feeds. A small tineid, *Homaledra sabalella*, also feeds on the foliage of this plant.

On the wild morning-glory vine are found the tortoise beetles, *Coptocycla aurichalcea* and *C. purpurata*, and a small tineid makes a serpentine-like mine in the leaves of the *Smilax*.

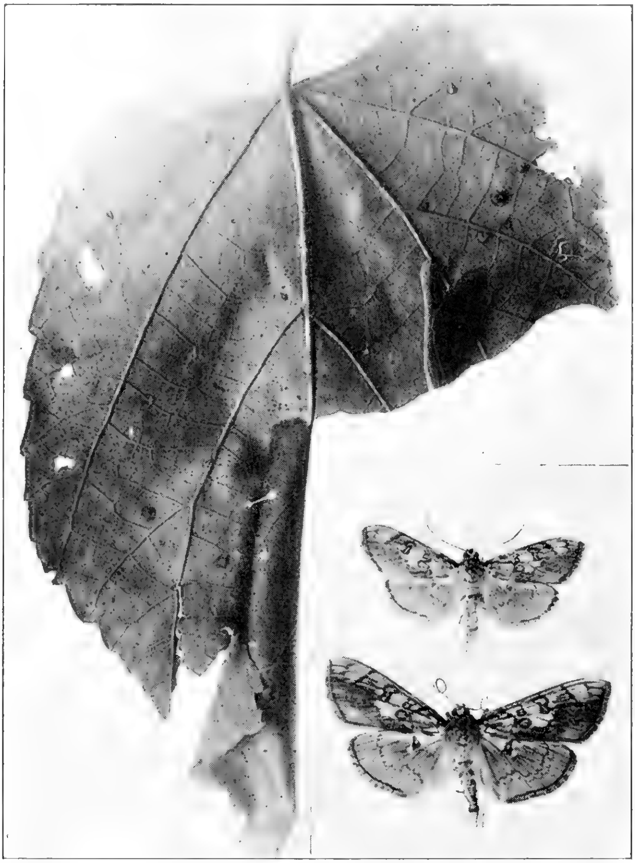

Fig. 11. The Basswood Leaf-roller, Pantagrapha limnata G. & R. Male and female moths and the work of the larvæ on a leaf of basswood.

III. TREE STRATUM.

In discussing the insects of the tree stratum, the most important or dominant trees will be taken up, giving a list of the insects associated with them, together with their relation to the host. Reference can be made to the annotated list for data on the different insects.

MAGNOLIA COMMUNITY.

The magnolia has very few enemies and this may account in a large degree for the long life of this tree.

Fig. 12. Work of the chrysomelid, *Octotoma plicatula*, on ash foliage.

Attacking the foliage: *Toumayella turgida*, *Coptocycla aurichalcea* and *Phyllocnistis magnoliella*.

At the flowers: *Thrips spinosus* and *Trichius piger*.

Parasitic: *Sympiesis* sp., and *Sagrammasoma multilineata*.

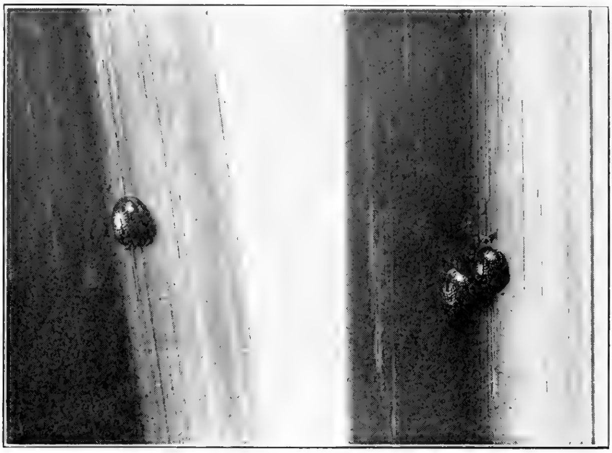

Fig. 13. *Porphyraspis cyanea* feeding on saw-palmetto.

Fig. 14. The Magnolia Scale (Toumayella turgida Ckl.)
Enlarged twice.

HICKORY COMMUNITY.

Attacking the foliage: *Serica vespertina, Anthonomus suturalis, Craponius inaequalis, Stictocephala festina, Apatela impleta,* and *Liothrips caryæ* var. *floridensis.* Galls caused by various species of *Phylloxera* are abundant on the leaves.

Predaceous: *Hyperaspis proba.*

Merely accidental: *Mesostenus* sp., and *Notoxus calcaratus.*

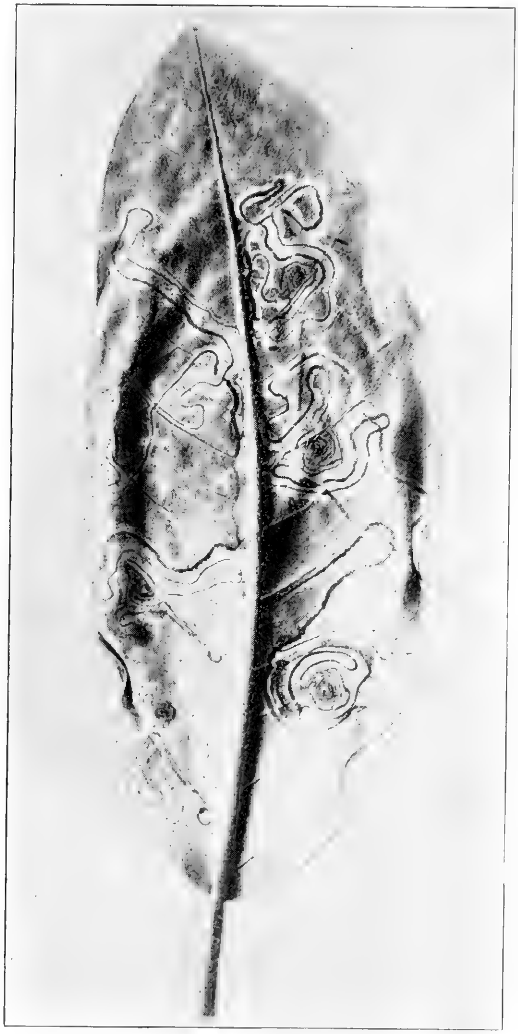

Fig. 15. Work of the Magnolia Leaf-miner (Phyllocnistis magnoliella Chamb.)

OAK COMMUNITY.

As a rule an insect that feeds upon one species of oak will be found to feed upon the other species. Therefore I shall list the oak feeding species under the one oak community. This rule does not hold good in every case, as many of the insects are limited to a single species of oak. The oak supports a larger number of insect species than does any one tree. And yet we find the giant oaks monarchs of the woods.

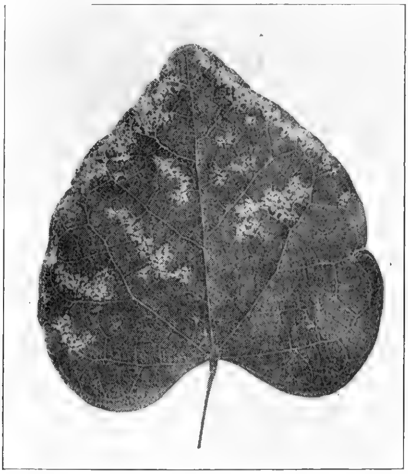

Fig. 16. Typical injury to the redbud by the leafhopper, *Erythroneura tricincta* Fitch.

Attacking the foliage: *Otiocerus degeerii, Stictocephala festina, Smilia camelus, Enchenopa binotata, Platycotis quadrivittata, Anthaxia cyanella, Brachys cuprescens, Diplotaxis languida, Lema brunnicollis, Lema conjuncta, Anomoea laticlavia, Coscinoptera dominicana, Bassareus conjestus, Cryptocephalus 4-maculatus* var. *flavipennis, Cryptocephalus guttulatus, Monachus auritus, Oedionychis fimbriata, Phyllotreta picta, Chalepus rubra, Metriona purpurata, Deloyala clavata, Attelabus analis, Pterocolus ovatus, Tachygonus lecontei, Pandeleteius hilaris, Prionomerus calceatus, Megalopyge opercularis, Stenoma humilis, Arogalea cristifaciella, Telea polyphemus, Amphibolips* sp., *Callirhytis batatoides, Holcaspis ficigera,* and *Andricus virens.*

Parasitic and predaceous: *Eupelmus auratus, Exochomus childreni, Brachyacantha dentipes, Enoclerus thoracicus,* and *Epitragus tomentosus.*

Occurring beneath bark: *Graphysurus fasciatus*, and *Adelina lecontei*.

Accidental: *Hymenorus obscurus*, *Tomoxia lineella*, *Notoxus calcaratus*, *Hypoprepia fucosa*, and *Hadena miseloides*.

BASSWOOD OR LINDEN COMMUNITY.

The basswood is met with throughout the hammocks and is a shade-enduring tree. It is attacked by numbers of insects and its blossoms furnish a rich collecting place. Among these is an undetermined leaf-tyer that renders the foliage unsightly.

Attacking the foliage: *Eriophyes abnormis*, *Gargaphia tiliæ*, *Gypona octolineata*, *Eutettix seminuda*, *Macrosiphum coryli*, *Crytocephalus badius*, *Chaetocnema confinis*, *Chalepus rubra*, *Pantagrapha limnata*, and *Phyllonorycter lucetiella*.

Accidental: *Celetes basalis*.

Relation of Piney Woods Insects To Their Environment.

I. GROUND STRATUM.

Although less study was devoted to the piney woods insects, it is at once apparent that the insect life in this association is much less varied and plentiful than that of the hammocks.

The subterranean fauna, however, is very characteristic. In spring, especially, low mounds of sand a foot or two in diameter, made by the rodent, *Geomys tuza floridanus*, are conspicuous and typical of this habitat. This rodent is known in Florida by the name of "salamander," a name which gives an entirely erroneous conception of the animal. Another misleading name is that of "gopher," given to the turtle *Testudo* or *Gopherus polyphemus*. The insect fauna of its long burrows has been studied by Hubbard (Insect Life, Vol. VI, 1894). This "gopher," together with the "salamander" and other animals are continually moving and stirring up every particle of the upper foot or two of the soil every few years. Ant hills, the pits of the ant-lion or so-called "doodle-bug," and the holes of tiger beetles are occasionally found.

II. FIELD AND SHRUB STRATUM.

In the spring and summer grasshoppers and leafhoppers are to be found in the tall wire-grass and broomsedge, although

not in exceedingly abundant numbers. This stratum is characterized by being somewhat lifeless and its insect inhabitants small and inconspicuous.

III. TREE STRATUM.

Nearly all of the trees have their own particular kind of galls. Galls caused by the Cynipids *Andricus virens*, *Callirhytis batatoides* and *Holcaspis ficigera*, (Fig. 17), are extremely

Fig. 17. *A*, Galls on *Quercus virginiana* caused by *Callirhytis batatoides* Ashm. *B*, Galls on same host caused by *Disholcaspis ficigera* Ashm.

abundant on the live oak, *Quercus virginiana*. The bases of the needles of pine are often enlarged to form galls by the Cecidomyid, *Cecidomyia brachynteroides*. (Fig. 18).

The scales, *Chionaspis pinifoliæ* var. *heterophyllæ* and *Lecanium parvicorne* (?) are found at certain seasons in large numbers on scattered individuals of the pine. These are heavily parasitized by chalcids. *From C. pinifoliæ* var. *heterophyllæ* were reared large numbers of *Aphelinus mytilaspidis* and *Prospaltella* sp. and from *L. parvicorne*, *Coccophagus immaculatus* and a species of *Aphycus*. The Florida wax scale, *Ceroplastes*

floridensis, was found infesting a branch of *Pinus palustris*, but this is of unusual occurrence. (Fig. 19).

Aphids are plentiful, together with their parasites and predators on the different trees and shrubs. To be particularly noted are the hickory *Phylloxera* galls and the large black pine aphid, *Lachnus pini*. The latter is parasitized by the hymenopteron, *Aphidius bifasciatus*. A clear and extremely interesting

Fig. 18. Galls of *Andricus virens* Ashm. on live oak, *Quercus virginiana*.

case of symbiosis exists between this aphid and its attendant ants.

Beneath and in the bark of the fallen pine are to be found the numerous galleries of the Scolytid bark beetle, *Ips calligraphus* (Fig. 20). Here are found many other insects, such as the buprestid borers, *Chalcophora* and *Buprestis*, and the wireworms, *Adelocera marmorata* and *Elater hepaticus*.

PINE COMMUNITY.

The several species of pine are treated under the one community.

Attacking the foliage: *Anisomorpha buprestoides, Cryptothrips pini, Lachnus pini, Chionaspis pinifoliæ* var. *heterophyllæ, Lecanium parvicorne* (?), *Ceroplastes floridensis, Lachnosterna prununculina, Polyphylla occidentalis, Polyphylla gracilis, Anomoea laticlavia, Cecidomyia brachynteroides,* and *Tolype minta.*

Fig. 19. *Kermes* scales that greatly resemble galls, on oak.

Bark and woodborers: *Ips calligraphus, Chalcophora virginiensis, Chalcophora georgiana,* and *Monohammus titillator.*

Parasitic and predaceous: *Aphelinus mytilaspidis, Prospaltella* sp., *Coccophagus immaculatus, Phymata erosa* var. *guerini, Repipta taurus, Hippodamia convergens, Coccinella sanguinea,* and *Chilocorus bivulnerus.*

Accidental: *Thyreocoris pulicarius, Cicada sordidata, Polemius limbatus, Photuris pennsylvannica, Bolbocerosoma farctum* var. *tumefactum, Callichroma splendidum, Typocerus zebratus,* and *Nezara viridula.*

CHINQUEPIN COMMUNITY.

The chinquepin is typically a piney woods form. While very few insects attack the foliage, the blooms of this tree form a rich and varied collecting ground. The blooming period

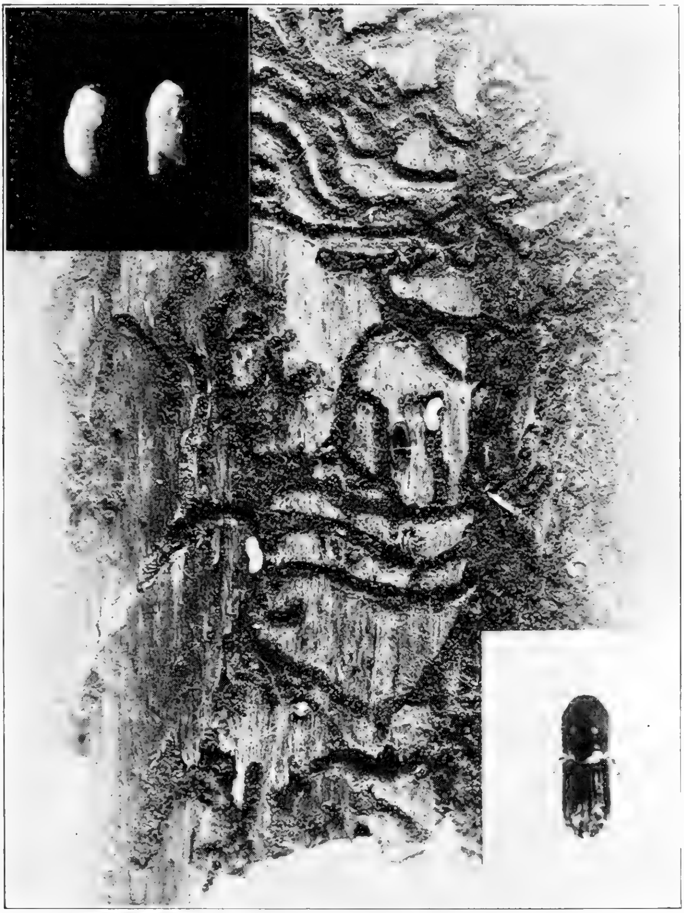

Fig. 20. Larvæ of *Ips calligraphus* Germ. and their galleries, natural size, in bark of pine tree. In the inserts, larva, pupa, and adult, enlarged.

lasts only two or three weeks, that for any one tree only a few days. The chinquepin begins blooming as early as April 26th and lasts some seasons as late as the first of June.

Attacking the foliage: *Diplotaxis bidentata* and *Diplotaxis frontalis.*

Predaceous: *Exochomus childreni* and *Chilocorus bivulnerus.*

At the flowers: *Pselliopus cinctus, Zelus cervicalis, Alydnus* sp., *Chauliognathus marginatus, Euphoria sepulchralis, Trichius delta, Trichius piger, Typocerus velutinus, Typocerus lunatus, Elaphidion mucronatum, Chlamys plicata, Oxacis thoracica, Rhipiphorus cruentus, Calandra oryzæ, Jurinea adjusta, Spallanzania hebes, Plagiprospherysa parvipalpis, Orthelia cornicina, Lucilia caesar, Tabanus mexicanus, Tabanus atratus, Elis subjens, Eumenes fraternus, Monobia quadridens, Polistes americanum, Chlorion caeruleum, Bembidula quadrifasciata, Bembex texana, Xylocopa virginica, Psithyrus laboriosus, Bombus pennsylvanicus, Apis mellifera, Dahana atripennis, Spragueia onagrus* and *Heliodenes* sp. (near or *H. bella*).

Accidental: *Macrophya formosa.*

Fig. 21. Work of the midge, *Cecidomyia brachynteroides*, on pine.

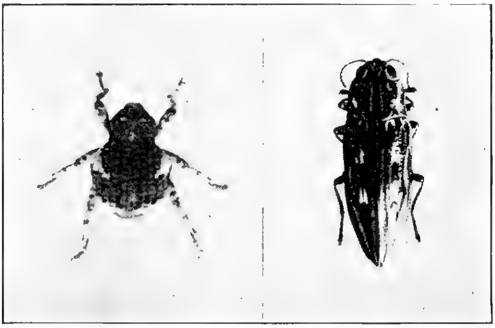

Fig. 22. *a*, The cactus-eating weevil, *Gerstaekeria hubbardi* Le C., on *Opuntia vulgaris*, enlarged. *b*, A pine borer, *Chalcophora virginiensis* Drury, nat. size.

PART III.

Annotated List of Insects.

ACARINA.

Eriophyes abnormis. This species of mite produces countless numbers of small galls on the leaves of basswood.

Trombidium locustarum Say. The Locust Mite. Locusts are frequently taken with these small red mites attached to their bodies. They are parasitic upon both the adults and their eggs.

Trombidium spp. Red-bugs. The six-legged larvæ of a number of species are the "red-bugs" or "chiggers" so commonly met with in the woods that attach themselves to man and cause serious annoyance. They burrow beneath the skin and produce inflamed spots. The mature mite is not parasitic, but wanders about feeding on small insects.

Tetranychus telarius Linn. Common Red-spider. This species of red-spider is abundant everywhere on the small weeds and plants of the hammocks.

INSECTS.

PLATYPTERA.

TERMITIDÆ.

Termes flavipes Koll. White Ant or Termite. White ants or termites are found the year round working in stumps and logs in an early stage of decay. A large colony of workers and soldiers were found working in a fallen limb of cypress December 21st.

These insects feed mainly upon woody material and are active agents in hastening the decay and destruction of the dead wood of the forest floor. (See Snyder, '15 and '16).

NEUROPTERA.

Chrysopa oculata Say. Lace-wing Fly. Both adults and larvæ of this species of aphis-lion may be found during the majority of the year in the hammocks.

Brachynemurus carrizonus. This and a number of other unidentified species of ant-lions have been taken.

ODONATA.

AGRIONIDÆ.

Agrion maculatum Beauv. Black Damsel-fly. This species is quite common March–June 5. It prefers the smaller streams, seeking the cool, shady places where the vegetation is rankest. It was abundant at Hogtown Creek April 9th.

Hetaerina americana Fabr. This damsel-fly is an uncommon one here. A specimen was taken by Prof. Watson at Hogtown Creek, May 7.

AESCHNIDÆ.

Anax junius Drury. Taken in magnolia hammock near stream, March 5.

Coryphaeschna ingens Ramb. This is our largest species and a rather common one. It is a very strong flier. March 10–April 25.

Tachopteryx thoreyi Hagen. A specimen taken at edge of magnolia hammock, March 25.

LIBELLULIDÆ.

Micrathyria berenice Drury. A very common although inconspicuous dragon-fly. Taken frequently at hammock edge. September 28–October 18.

Perithemia domitia Drury. This is a rather common species here and is frequently taken at hammock edge, although more abundant at wild flowers in open fields. There is a marked sexual dimosphism in the species. May 16.

Tramea carolina Linn. The Saddle-back Dragon-fly. This is one of our earliest and most abundant forms. It is typical of hammock and forest edge. February 26–April 25.

Erythemis simplicicollis Say. One of our most common species, occurring at hammock edge. Also taken in flatwoods. April 20–September 4.

Libellula auripennis Burm. Golden-winged Dragon-fly. A typical hammock and forest-edge insect. Has been taken only during May, but it is very abundant then. May 15–26.

Libellula axillena Westw. Several specimens taken by Prof. Watson at hammock edge May 17.

Libellula vibrans Fabr. A common insect about the stream at Hogtown Creek. April 5–June 11 (J. R. Watson).

Pachydiplax longipennis Burm. Abundant at Hogtown Creek, April 1–19.

ORTHOPTERA.

FORFICULIDÆ.

Vostox brunneipennis Serv. This pretty and striking ear-wig is found in large numbers beneath loose bark of old dead magnolia trees, together in association with *Eurycotis floridana.*

BLATTIDÆ.

Eurycotis floridana. The Large Wood Roach. This large wood roach inhabits decaying stumps, but is characteristically found beneath loose bark of decayed trees and frequently beneath corded wood.

I have found large numbers under bark pulled from trunk of a dead magnolia.

These roaches give off a very strong, quite distinctive, and very offensive odor, especially when handled.

Periplaneta americana Linn. The American Roach. Found occasionally in same habitats as the above species.

MANTIDÆ.

Stagmomantis carolina Johannsen. Praying Mantis or Devil's Horse. This is a forest margin insect and is rather scarce. The eggs are laid in masses and overlaid with a hard covering of silk; the top of the masses having the appearance of being braided. They are deposited on numerous kinds of vegetation. September 15–October 13.

Thesprotia graminis Sc. Smaller Praying Mantis. This is a forest-margin insect and is not very abundant.

PHASMIDÆ.

Anisomorpho buprestoides Stall. Lubberly Walking-stick. This species seems to be the commonest as well as the largest walking-stick found here. It is also sometimes known as the "Musk Mare." It has been taken on a variety of vegetation. A pair in copula on *Pinus taeda*, November 19.

The difference in size of the sexes is most striking. The female is twice the size of the male in length and much stouter in proportion. The females vary from 3 to 3¼ inches and the males from 1½ to 1¾ inches in length.

When disturbed, these insects throw off a volatile and acrid liquid with an odor that resembles that of peppermint somewhat. It is extremely penetrating, very much like ammonia, causing a similar smarting of the nostrils. This odor comes from the milkish fluid that is ejected from two pores on the prothorax and it clings to one's fingers and is still strong an hour afterwards. When the secretion is first ejected, the odor is distinct a couple of feet away.

Diapheromera femorata Say. Forest Walking-stick. This walking stick is distinctly a forest-inhabiting insect and occasionally becomes of economic importance. It is not a common insect in this region. Its life-history and habits have been studied by Riley ('78). August 15.

ACRIDIDÆ.

Schistocerca alutacea Harris. This seems to be the most abundant grasshopper here and is found in nearly all habitats the year round. Numbers of a dipterous parasite, *Sarcophaga opifera* Coq., were reared from adults.

Schistocerca americana Drury. Bird Grasshopper. Is more abundant than the above species during the winter and is found in the same habitats.

Dichromorpha viridis Sc. A green, short-winged form that inhabits grassy spots in hammock. September 30.

Arphia granulata Sauss. Yellow-winged Singer. This species has been taken by Prof. Watson as follows. Abundant in scrub oak woods March 29; Piney woods, September 27; Flatwoods, October 11–18.

Paroxya atlantica Sc. Taken occasionally at hammock-edge; also in flatwoods. August 27–October 18.

Stenacris vitreipennis Marsch. A specimen taken by Prof. Watson at border-line between low piney woods and hammock, November 30.

Neotettix coarctatus Hanc. Abundant in rushes and low herbage along banks of moist area at hammock edge near the target range, April 15.

Tettigidea lateralis lateralis Say. This is the most abundant grouse-locust here. Found in the same habitat as the above species.

LOCUSTIDÆ.

Belacephalus spp. The nymphs, especially of this genus are met with frequently under old logs and leaves in the hammocks.

Pyrgocorypha uncinata Harris. Found occasionally in hammocks in same habitats as the above species.

Microcentrum rhombifolium Sauss. This is a typical hammock insect, although not very abundant. Numbers of the egg-parasite of this species, *Eupelmus mirabilis* Walsh, have been reared.

GRYLLIDÆ.

Gryllotalpa borealis Burm. Common Mole-cricket. This species occurs in numbers along the moist banks of streams running along edge of hammock.

Gryllus. The home of this insect is beneath logs and rubbish along forest margin.

Orocharis saltator Uhler. A ♀ was taken hibernating in a decayed limb which was hanging in the branches of a tree in high hammock January 28. Prof. Watson took a ♂ around an injured tree in deep and low hammock, April 25. This is one of the most common tree-crickets found in the hammocks.

Hypithus agitator quadratus Sc. A ♀ was taken on iron weed (Vernonia angustifolia) along bank of Hogtown Creek, October 1.

THYSANOPTERA.

Thrips spinosus Morgan. The Magnolia Thrips. Is found in the blossoms of Magnolia grandiflora during May.

Frankliniella bispinosus projectus Watson. Florida Flower Thrips. This is our most abundant species of thrips and is found in blossoms of numerous plants the year round. It has been taken in blossoms of *Cercis canadensis* (March), *Aesculus pavia*, *Crategus aestavalis*, and numerous others. It was found breeding in numbers during March in the thimble-shaped rolls of the leaf-rolling beetle, *Attelabus analis*.

Heterothrips aesculi Watson. The Buckeye Thrips. Abundant in flowers of the wild buckeye, *Aesculus pavia*, in March. Taken also in the blooms of *Azalea nudiflora* at Hogtown Creek, March 9.

Cryptothrips pini Watson. The Pine Thrips. Prof. Watson has taken this species by beating pine from March–May.

Liothrips caryæ var. **floridensis** Watson. Hickory-gall Thrips. Taken in Phylloxera galls on leaves of hickory in April, May and June.

Anthothrips dozieri Watson. Collected by the writer by beating *Ostrya* in March.

HEMIPTERA.

CAPSIDÆ.

Halticus citri Ashm. Flea-hopper. The main food plant of this species is beggar weed. It has been taken by sweeping low growth in low hammock edge at Lake Alice. Breeds during the winter in greenhouses and has been taken in the open from April through August.

REDUVIIDÆ.

Zelus bilobus Say. This predaceous bug is quite common in the hammocks. Nymphs abundant on *Ostrya*, March 26 and April 17.

Zelus cervicalis Stal. Taken at bloom of chinquepin, May 20.

Narvesus carolinensis Stal. Taken in hammock, June 26.

Pselliopus cinctus Fab. Common in hammocks. A visitor at chinquepin bloom May 12 (J. R. Watson). September 30.

Repipta taurus Fabr. Met with frequently in magnolia hammock and also on pine. July 30.

Sinea diadema Fabr. Rapacious Soldier-bug. A pair of this insect taken in copula between two oak leaves at edge of hammock, January 20. Nymphs abundant on *Ostrya*, March 26 and April 17. The little that is known of its life-history has been recorded by Ashmead ('95).

PHYMATIDÆ.

Phymata erosa var. **guerini** L. & S. A specimen of this species was taken on Long-leaf pine November 19. It is not uncommon here and is taken often at blooms of various flowers.

TINGIDIDÆ.

Gargaphia tiliæ Walsh. Basswood Lace-wing Bug. This tingid was very numerous on the under surfaces of the leaves of basswood throughout the hammocks April 2. Its work was decidedly noticeable, causing yellowish spots on the leaves. A few adults, the first of the season, were taken March 5.

Leptoypha sp. nov., close to **L. costata.** Wild Olive Tingid. This species occurs abundantly on the under surfaces of the leaves of *Osmanthus americanum.* Its work is also very noticeable, causing yellowish spots to show through on the upper surface. (See Osborn and Drake, '16). Work was noticeable and a dead nymph found March 5. Nymphs and adults abundant, August 13.

PYRRHOCORIDÆ.

Largus succinctus Linn. Taken on an old log in hammock, January 16.

Dysdercus suturellus Say. This species is taken occasionally.

DYSODIIDÆ.

Mezira granulata Say. A specimen was taken on foliage of shrub at edge of hammock, April 1.

COREIDÆ.

Euthoctha galeator Fab. Abundant at blossoms of wild cherry, March 7. Hammock, April 16.

Acanthocephala femorata Fab. Large-footed Plant Bug. This species is very abundant and is often taken at hammock edge. Its favorite host is the bull thistle. Pairs taken copulating, April 4.

Leptoglossus phyllopus Linn. Leaf-footed Plant Bug. Abundant nearly everywhere, especially at the blooms of thistles. Plant bugs begin to get abundant about the first of March and remain abundant nearly all season.

ALYDIDÆ.

Leptocorisa tipuloides DeGeer. Abundant the year round on various grasses. January 28.

Alydnus sp. Abundant at blooms of chinquepin, May 20.

THYREOCORIDÆ.

Thyreocoris pulicarius Germ. A specimen taken on pine, April 17.

PENTATOMIDÆ.

Mormidea lugens Fab. Very abundant on weed at hammock edge, April 1.

Euschistus servus Say. Abundant at blossoms of wild cherry, March 7.

Euschistus variolarius Beauv. Not as abundant as the above species.

Thyanta custator Fab. Taken on haw bush, March 10.

Nezara viridula Linn. Green Pumpkin Bug. This insect is very abundant nearly everywhere and is of considerable economic importance. I have taken this species hibernating in large clusters beneath loose bark pulled from dead oak trees.

Euthrynchus floridanus Linn. Rather common and preys upon various insects. I found one sucking an adult lady-bird, *Chilocorus bivulnerus*, April 17.

SCUTELLERIDÆ.

Chelysoma guttatum H. Schf. Taken on foliage of the red haw, March 8.

CICADIDÆ.

Cicada sordidata Say. This is one of the commonest cicadas found here. It is heard singing in the tops of young pine seedlings, hiding away amid the foliage, during August and September.

Like all cicadas, the nymphs live underground, sucking the juices from the roots of trees. Upon reaching maturity, they come up to the surface and crawl up the trunk of some nearby shrub or tree where their shed nymphal skins are often found clinging to the trunks.

Cicadas first make their appearance at Gainesville about the middle of April.

Cicada hieroglyphica var. **Johannis** Walker. A specimen was taken at Hogtown Creek, June 28, by Prof. Watson.

Tibicen simularis S. & G. A dead specimen was found by Prof. Watson in a road leading through piney woods, August 20.

CERCOPIDÆ.

Monecphora bicinicta Say. Taken in hammock, June 29, although not a typical hammock form.

MEMBRACIDÆ.

Acutalis tartarea var. **semicrema** Say. Abundant on *Eupotorium(?)* near the edge of Lake Alice, April 18.

Stictocephala festina Say. Taken on young hickory, March 3. On oak, April 3.

Smilia camelus Fabr. On oak at edge of hammock, April 10–13.

Smilia fasciatus M. & S. Taken in association with *S. camelus* on oak, March 16.

Archasia belfragei Stal. Not very common, occurring on oak at hammock edge, April 18.

Cyrtolobus vau Say. One of our most common treehoppers. Last instar nymphs and adults were found on *Quercus virginiana* at hammock edge, March 18–19. Both adults and nymphs greatly resemble leaf buds.

Ophiderma flavicephala Godg. A very common species on oak. March 18–April 18.

Ophiderma sp. nov. A single specimen of this blackish treehopper was taken hibernating in a decayed limb in hammock, January 28.

Entylia concisa Walk. Very abundant on young hickory shrubs in March and is also found on the wild buckeye, *Aesculus pavia*, and the thistle.

Enchenopa binotata Say. Abundant on oak, April 6.

CICADELLIDÆ.

Agallia 4-punctata Prov. A number taken on solanaceous weed near bank of Hogtown Creek, April 9.

Oncometopia undata Fabr. A specimen taken in magnolia hammock by Prof. Watson, July 30. This insect attacks citrus and roses and is of considerable economic importance.

Cicadella occatoria Say. This very pretty leafhopper is rather common here. It has been taken on blackberry and ragweed, July 8, on sweet bay, July 15, and by sweeping low herbage at hammock edge, April 18.

Kolla geometrica Sign. Taken on a weed at Hogtown Creek, April 11. On low herbage at edge of Lake Alice, April 18.

Tettigonella versuta Say. Taken on sweet bay and a number of weeds in abundance, July 8.

Gypona octolineata Say. One on basswood leaf, April 6.

Gypona grisea Spang. (?). A male of what is probably this species was taken on grass at hammock edge, July 16. Female only has been described.

Platymetopius frontalis Van D. Numbers on a species of mint (?) growing along road to Hogtown Creek, April 11. According to Osborn ('15, p. 113), it ordinarily occurs in grass-land and is frequently taken in adult form from oak trees.

Eutettix seminuda Say. Taken on basswood leaf, April 13. Rather common here.

Phlepsius excultus Uhl. Abundant. Taken in hammock, June 8.

Scaphoideus auronitens Prov. A specimen was taken on a solonaceous weed near bank of Hogtown Creek, April 9. One was taken on ash, May 5. According to Osborn ('15, p. 115), this species occurs only in shaded, wooded places.

FULGORIDÆ.

Otiocerus degeerii Kirby. A specimen was taken in hammock on an oak leaf, March 3.

Otiocerus abbotti Kirby. A rare species. A colony of eleven adults was taken on the undersides of ash leaves in magnolia hammock, March 30.

Ormenis septentrionalis Spin. Occurs on poke weed along the edge of hammock. July 8.

Ormenis pruinosa Say. Also an inhabitant of the hammocks.

APHIDIDÆ.

Drepanaphis monelli Davis. A winged female with a young colony of about eight on under surface of buckeye leaf, March 12.

Macrosiphum coryli Davis. A winged female with a young colony of eight on underside of basswood leaf, March 12.

Macrosiphum illinoisensis Shimer. Taken by A. C. Mason on wild grape, April 23–June 4. According to him, it is fairly abundant at this time of the year.

Pemphigus attenuatus Osb. A colony of this aphid was taken by A. C. Mason on smilax or green-briar, April 23. This was the only colony found, although a diligent search for others was made.

Lachnus pini Linn. This large species is common throughout the year on pine, but more abundant during the winter. It is parasitized by the hymenopterous parasite, *Aphidius bifasciatus* Ashm.

ALEYRODIDÆ.

Aleyrodes mori Quaint. This aleyrodid has been taken on a number of hosts in the hammocks. The under surface of nearly every leaf of a large holly tree was found covered with this species, December 2. They were heavily parasitized by an unknown chalcid.

COCCIDÆ.

Chionaspis pinifoliæ var. **heterophyllæ** Cooley. This scale is at times rather abundant on pine foliage. The writer has reared from this species the hymenopterous parasites, *Aphelinus mytilaspidis* and *Prospaltella* sp. in numbers. November 19–December 20.

Toumayella parvicorne Ckll. Also found on pine, but in sparing numbers, November 19. This parasite, *Coccophagus immaculatus*, and a species of *Aphycus* (?) were reared from this host.

Ceroplastes floridensis Comst. A branch of long-leaf pine was found infested with this scale, December 2.

Toumayella turgida Ckll. This scale is quite characteristic of the magnolia, being found on the underside of the leaves. Large numbers of the male scales were collected February 10. No females were to be found. From a small branch of six heavily infested leaves were reared nearly 500 males and 30 specimens of the parasite *Coccophagus immaculatus*. It is during this month that these scales are most abundant.

Aspidiotus hederæ Vall. This species is often met with on the leaves of swamp red bay, *Persea pubescens*, but is never abundant.

Coccus sp. The males of this species closely resemble those of *Toumayella turgida*, but are smaller in size. It is quite characteristic of red bay, *Persea borbonia* and is most abundant during February. A species of *Coccophagus* was reared in numbers.

COLEOPTERA.

CICINDELIDÆ.

Cicindela punctulata Fab. This is the most common species of tiger-beetle here. It is found along the sides of roads and in pathways running through open hammock.

Cicindela scutellaris var. **unicolor** Dej. Met with in the same habitats as the above species, but is not as abundant.

CARABIDÆ.

Omophron labiatum Fabr. This oval, convex carabid has been taken by the writer only beneath arc lights, but according to W. S. Blatchley, it occupies holes in the wet banks along the margin of streams, ponds, and sinks.

Pasimachus strenuus Lec. Met with occasionally beneath old logs. April 9–22.

Pasimachus subsulcatus Say. Occurs in the same habitats as the above species. April 4.

Morio monilicornis Latr. Plentiful beneath the bark of dead pine tree in hammocks, March 1.

Dicaelus alternans Dej. A single specimen taken beneath log, alluvial floodplain at Hogtown Creek, April 11.

Galerita janus Fabr. One of the common carabids. Found in abundance beneath old logs the year round.

Galerita lecontei Dej. Same habitat as the above species, but not as abundant.

Plochinous amandus New. A specimen was taken in caterpillar's old nest on wild olive (Osmanthus americanum), August 13.

Apenes sinuata Say. A single specimen was taken in leaf-tyer's (Laverna sabellela) nest on *Phoenix canariensis,* March 1.

Callida decora Fabr. Beneath bark of decayed oak stump, January 16. Several taken from under bark of small oak limbs in pile, in association with *Adelina lecontei,* February 4.

Brachynus stigycornis Say. Found beneath log at edge of hammock, May 1.

GYRINIDÆ.

Dineutes carolinus Lec. Abundant in the water of streams and sinks.

Members of the whirligig family of beetles, when handled give off a milky fluid which usually has a disagreeable odor. In certain species the odor is very pleasant and the name sweet-bugs is often applied to them.

COCCINELLIDÆ.

Megilla maculata DeG. This species has been taken several times, but is not abundant.

Hippodamia convergens Guer. A very common species. It is very abundant on the bull thistle in April.

Coccinella sanguinea Linn.

Found abundantly throughout most of the season.

Chilocorus bivulnerus Muls. This lady-bird is found the year round and is probably our most useful native coccinellid.

Exochomus childreni Muls. This small reddish cocinellid was abundant on oak foliage, April 16. On chinquepin leaf, April 29.

Brachyacantha dentipes Fabr. A single specimen was taken on oak foliage in piney woods, April 16. On oak foliage at hammock edge, April 3.

Brachyacantha querceti Sz. Taken on buckeye foliage at Hogtown Creek, March 9. Prof. Watson took a specimen in same locality March 5, in leaf-roller's nest, feeding on the remains of the inhabitant, which it had apparently killed.

Hyperaspis proba Say. One on hickory leaf, April 11.

Scymnus fraternus Lec. Very abundant during March in the blooms of *Crategus* and on the foliage of *Aesculus pavia.*

EROTYLIDÆ.

Megalodacne heros Say. Several of this handsome erotylid were taken hibernating beneath loose bark of a large magnolia log, January 25.

Tritoma festiva Lac. A number taken beneath bark of fallen oak, February 13.

Tritoma thoracica Say. One taken on ash leaf in hammock near stream, April 5.

HISTERIDÆ.

Platysoma carolinus Payk. Probably our most common species of Histerid. Taken beneath pine bark of decaying log, February 19.

Paromalus aequalis Say. This curious little beetle occurs abundantly beneath the bark of fallen oaks. February 7–March 6.

ELATERIDÆ.

Adelocera marmorata Fab. Has been taken from beneath bark pulled from decayed pine and oak trunks, but is a scarce species. March 1–9. The larvæ are probably predaceous.

Alaus oculatus Linn. Is found wintering in the adult stage in decayed stumps in plentiful numbers. A common, though interesting, species.

Alaus myops Fab. This species is found in the same habitats as the above species, but is not as abundant.

Cardiophorus sp. An unidentified member of this genus is very abundant on the foliage of various trees and shrubs in the hammocks. March 1.

Monocrepidius lividus Deg. Found abundantly on the foliage of various trees and shrubs. March 15–August 17.

Elater hepaticus Melsh. Six of this small brown elaterid were taken in decayed piece of limb suspended in small tree, January 28.

Orthostethus infuscatus Germ. This beetle passes the winter in the pupal stage, issuing the latter part of April. The larva is cylindrical, very highly chitinized, with a thimble-shaped 9th abdominal segment. It is a typical inhabitant of decaying oak and pine logs, where it may be found the year round. Adults, April 20–26.

Limonius pubicollis Lec. This species occurs on the foliage of *Ostrya* and shrubs in the hammocks in sparing numbers. March–April 11.

BUPRESTIDÆ.

Chalcophora virginiensis Drury. A common species here. The larvæ bore in pine.

Chalcophora georgiana Lec. Has the same host as the above species, but is not as abundant.

Dicerca obscura Fab. A specimen taken on pine log, January 3, by Prof. Watson.

Buprestis decora Fab. Two fallen specimens taken near pine trees; one contained a large number of eggs, March 29. This species evidently emerges about this time of the year.

Anthaxia cyanella Gory. This pretty bluish-green closely resembles an *Agrilus* The adults have been taken on various oaks and only from March 27–April 15. They were abundant on young red oak bushes in open fields April 15.

Chrysobothris femorata var. Fab. Taken occasionally at flowers. At dogwood blossom, April 13.

Acmaeodera tubulus Fab. A common species at the blossoms of wild plum, dewberry and bull thistle. March 2–April 11.

Acmaeodera ornata Fab. Taken at blossoms occasionally. May 1.

Agrilus subcinctus Gory (?). Rather abundant, copulating on ash leaves April 4–5. A single specimen on linden leaf at hammock edge, March 24.

Agrilus dozieri Fisher. Numbers of what is a new species, closely resembling *A. ruficollis,* have been taken on the foliage of *Ostrya* at a number of places in the hammocks; only on this host. March 30–April 5.

Taphrocerus agriloides Cr. This species was rather abundant on nut grass and low herbage at hammock edge, April 1–3.

Brachys cuprescens Blatch. The adults appear the latter part of March and are present for only a few weeks. During this time they are very abundant, however. The larvæ are leaf-miners on oak which is also the food of the adults. March 24–April 16.

LAMPYRIDÆ.

Calopteron reticulatum Fab. This large handsome species is found on the foliage of various shrubs and trees, March 5–June 25.

Celetes basalis Lec. Taken on basswood leaf, April 2.

Photuris pennsylvanica DeG. Taken on *Pinus palustris* at night, June 9.

Chauliognathus marginatus Fab. Our most common species and abundant everywhere, especially at the blossoms of flowers. Taken nearly the whole year round.

Polemius limbatus Lec. Taken on long-leaf pine needles, December 4.

CLERIDÆ.

Enoclerus thoracicus Oliv. Beaten from oak foliage, April 18.

LUCANIDÆ.

Passalus cornutus Fab. An extremely abundant inhabitant of half decayed logs and stumps.

SCARABAEIDÆ.

Canthon depressipennis Lec. This little green or black dung beetle is very common from April to September.

Canthon laevis Drury. Our most abundant species of dung beetle and is met with along roads, rolling their balls of dung. April–September.

Choeridium lecontei Harold. Taken occasionally. May 27.

Copris carolina Linn. This species is most abundant during June.

Copris minutus Drury. A common species and is abundant nearly the year round. Very abundant at lights, February 5.

Phanaeus igneus MacL. A rather common species the year round, flying around dung in roads. While in flight, their buzzing closely resembles that of the bumble-bee. January 5–March 26.

Phanaeus carnifex Linn. Closely resembles the above species, but is not near so abundant.

Onthophagus hecate Panz. This very small beetle is found frequently in dung.

Bolbocerosoma farctum var. **tumefactum** Beauv. A specimen was taken from beneath bark of fallen pine, August 3. Prof. Watson took a specimen flying over grass-wet prairie July 30.

Trox suberosus Fabr. Taken at dead rat, June 28.

Diplotaxis languida Lec. Taken at night eating oak foliage, May 2. March 12–May 2.

Diplotaxis bidentata Lec. Numbers taken at night feeding on chinquepin foliage, April 24. Varies in color from brown to black.

Diplotaxis frontalis Lec. Taken at night feeding on chinquepin foliage, April 24. Several at lights, April 6.

Serica vespertina Gyll. A specimen taken eating foliage of young tender hickory, March 10.

Lachnosterna prununculina Burm. Several at lights, June 6. A swarm of hundreds was eating the foliage of *Pinus palustris* at night, June 8. I was attracted by the loud buzzing of them overhead.

Anomala semilivida Lec. A specimen taken on beggarweed, August 13.

Anomala marginata Fabr. One taken beneath log at Hogtown Creek, May 23. This species feeds on the foliage of wild grape and various trees.

Strigoderma pygmaea Fabr. Found abundantly on various weeds. April 20–August.

Dynastes tityrus Linn. The Rhinoceras Beetle or Betsy Bug. Found occasionally beneath old logs. It is said to live in the larval stage in old rotten wood. Found most abundantly beneath arc-lights in July.

Strategus antaeus Fabr. Found occasionally beneath old logs. July.

Stephanucha (Euphoria) areata Fabr. This species has been found only along sandy roads. January 16–February 19. Prof. Watson took one in road at Hogtown Creek, January 25. This is a rather rare species here.

Euphoria sepulchralis Fabr. An extremely abundant species, occurring at the blooms of chinquepin and especially at bull thistle. Abundant from March 25–August 16.

Euphoria inda Linn. Occurs at blossoms of various plants, but is an uncommon species here. October 9.

Trichius delta Forst. First made their appearance at chinquepin blooms, April 28. Taken at blooms of Salvia, Cherokee rose, and other flowers. These beetles were more or less abundant through June 5. An adult was taken on golden rod bloom August 9.

Adults were reared from larvæ in oak stump. They greatly resemble *Lachnosterna* larvæ, but are smaller in size and of a more creamish color.

Trichius viridulus Forst. A specimen taken in bloom of southern pawpaw along roadside to Hogtown Creek, May 23. This is a rare beetle here as elsewhere.

Trichius piger Fabr. Occurs on flowers of various kinds, including New Jersey tea and the magnolia. Is not as abundant as *T. delta* and apparently hasn't as long a season as that species. May–June.

Polyphylla occidentalis Linn. This species feeds on the foliage of pine and has been taken from April 25–June 6.

Polyphylla gracilis Horn. Also feeds on pine foliage, but is not very abundant. April 28–May 20.

CERAMBYCIDÆ.

Derobrachus brevicollis Serv. This is a very common visitor to porch lights during June. It is said to breed in old logs.

Chion cinctus Drury. A specimen taken on pine log by Prof. Watson, January 3. A very common species at lights, January–April 15.

Molorchus bimaculatus var. **semiustus** Newm. Rather common at blossoms of dogwood and *Crategus*, March 11–12.

Molorchus bimaculatus var. **corni** Hald. A single specimen of this variety taken at dogwood blossom, March 10.

Molorchus bimaculatus var. A single specimen of a black variety of *bimaculatus* taken at blossom of *Crategus*, March 12.

Rhopalophora longipes Say. A specimen of this slender bluish-black cerambycid was taken at dogwood blossom, March 11.

Callichroma splendidum Lec. One taken by O. Manecke in piney woods, flying from the bark of one pine tree to another, making a loud buzzing noise as it flew.

Neoclytus erythrocephalus Fab. A pair was collected in copula on fence at Hogtown Creek by Prof. Watson February 20. The larvæ breed in a large variety of trees.

Xylotrechus sagittatus Germ. A specimen taken by Prof. Watson on recently cut pine stump at Hogtown Creek, September 24.

Typocerus velutinus Oliv. Taken at chinquepin bloom by Prof. Watson, May 10.

Typocerus zebratus Fab. Taken on pine foliage in March. On small thistle in open field, April 20.

Typocerus lunatus Fab. A specimen taken at bloom of chinquepin by Prof. Watson, May 12.

Monohammus titillator Fab. This species is known as the Southern Wood-Sawyer and does a tremendous amount of damage to pine timber in the southern states. June 9–October 20.

Graphysurus fasciatus DeG. Several newly emerged adults and pupæ were taken beneath bark pulled from fallen oak trunk, February 7. A specimen was taken at lights September 25.

Oberea ocellata var. **plagiata** Casey. A single specimen was taken on weed at Hogtown Creek, May 23.

Elaphidion mucranatum Fab. A specimen taken by Prof. Watson at chinquepin bloom, May 10. Taken at lights, June 8.

CHRYSOMELIDÆ.

Lema solani Fab. Numerous at Hogtown Creek, April 9, eating the foliage of a solanaceous weed. March 14–April 9.

Lema brunnicollis Lac. A specimen was taken by Prof. Watson in live oak hammock, August 20. Abundant on low oak bushes and weeds in open field, April 11–15.

Lema conjuncta Lec. Taken in flight along road through hammock, May 1. A specimen was swept from oak foliage, April 1.

Anomoea laticlavia Forst. This species has been taken feeding on pine foliage June 8. Taken on a weed at Hogtown Creek, April 9.

Coscinoptera dominicana Fab. A specimen taken by umbrella-beating oak foliage, April 18.

Chlamys plicata Fab. Numbers of this queer-looking beetle were taken on chinquepin blooms, evidently eating the pollen, May 20.

Exema gibber Oliv. Taken in the hammocks, April 2.

Bassareus congestus Fab. Several have been taken on oak foliage. July 5–24.

Cryptocephalus 4-maculata var. **flavipennis** Hald. Beaten from wild cherry in bloom on road to Hogtown Creek, March 9. Taken also on oak and wild buckeye foliage. April 3–18.

Cryptocephalus guttulatus Oliv. Taken on weed at Hogtown Creek, April 9. On oak foliage, April 3.

Cryptocephalus badius Suffr. A number of specimens taken on basswood, July 12–14.

Monachus auritus Hald. A few on oak foliage in hammock, April 4.

Monachus thoracicus Cr. Large numbers of this little bronze chrysomelid were taken at wild plum blossoms, February 18–20. Abundant at cherry laurel blooms, March 1. At blooms of wild cherry in plentiful numbers, March 7–9.

Trirhabda brevicollis Lec. This beetle makes its appearance every year about the first of April, having only a single brood a year. Some years it completely defoliates all the prickly ash. The first larvæ of the season have been taken April 1. The pupal stage lasts only for a few days.

Galerucella notulata Fab. Taken on ragweed (Ambrosia), July 6.

Oedionychis 6-maculata Ill. Abundant on foliage of ash, together with *O. scalaris*, April 5. This beetle is astonishingly quick in its movements.

Oedionychis scalaris Melsh. Taken on ash, but not as abundant as the above species. April 5–6.

Oedionychis fimbriata Forst. Beaten from oak foliage, April 18.

Disonycha glabrata Fab. Abundant on bull thistle while in bloom, April 20. Large numbers riddling the foliage of pigweed (Amaranthus), May 15. A few were taken on corn plants, August 16.

Disonycha triangularis Say. Taken by sweeping low foliage; moist hammock edge at target range, April 15. Taken under old log hibernating, (C. Nieland).

Phyllotreta picta Say. Very abundant on young oak foliage, March 10–April 2.

Haltica chalybea Ill. This species winters over in the hammocks in Spanish moss. An adult was taken as early as February 18, at wild plum blossom and by the 27th large numbers were beginning work on the foliage of the wild grape. Hundreds were swarming everywhere, May 5.

Blepharida rhois Forst. Adults and larvæ of this "jumping sumac beetle" were very abundant on young sumac April 11–15. Larvæ were also abundant September 29, so that there must be a number of broods per year.

Chaetocnema confinis Cr. Occurs in abundant numbers in the hammocks on the foliage of basswood, wild cherry, buckeye, and various other trees and shrubs. March 3–April.

Octotoma plicatula Fab. The first of the season was taken on buckeye leaf, March 6. The ash is their first choice as a food plant and by March 25 large numbers are at work on this plant. They are to be found for only a few weeks and as far as I have observed, have only a single brood a year.

Chalepus rubra Weber. Several have been taken between leaf-tyer's old nests in the hammock on oak from June 25–March 2. They begin to get abundant on the linden or basswood, the foliage of which they eat, by the middle of March. As with the above species, they are present in numbers for only a few weeks and then disappear. A single specimen was taken on oak, May 1. A pair of this species was taken on linden in copula, June 11.

Chalepus notatus Oliv. A few of this scarce beetle have been taken on blackberry, Ostrya, and oak. April 4–5.

Chalepus bicolor Oliv. Two specimens were taken by sweeping low foliage at hammock edge, April 1.

Metriona (Coptocycla) purpurata Boh. This species has been taken on buckeye, oak, and wild morning-glory vines. March 15–May 15. It is rather uncommon and its favorite food plant is *Ipomoea*.

Deloyala (Coptocycla) clavata Fab. A specimen of this rough-backed cassid was taken on a weed at Hogtown Creek, April 9. Several specimens were taken on oak foliage, December 2–3.

This is more of a northern insect, and this record extends the distribution of the species for a considerable distance south of its usual range.

Chirida (Coptocycla) guttata Oliv. This species occurs on wild sweet-potato vines and has been taken on wild mustard foliage. April 20–August 12.

Porphyraspis cyanea Say. Characteristic of saw-palmetto on which it only is found. January 1–October 28.

Chelymorpha argus Licht. A specimen taken hibernating in crevice of old log at hammock edge (C. Nieland), February 18.

TENEBRIONIDÆ.

Nyctobates barbata Koch. Found beneath loose bark of decaying tree trunks. It is typical of this habitat. October 20.

Epitragus tomentosus Lec. This is a very common species and is found especially on oak the year round. According to Prof. Watson this beetle is similar to the lady-birds in habits, feeding on various scales.

Polypleurus nitidus Lec. Very common under old logs and boards on the forest floor in both piney woods and hammock margin. January 14–February 3. Assimilates death when disturbed.

Polypleurus geminatus Sol. More uncommon than the above species, but typical of the same habitat. Found in association with *P. nitidus*. January 14–February 3.

Uloma impressa Melsh. Large numbers beneath bark of fallen pine log, November 19.

Uloma punctulata Lec. Abundant beneath pine bark in association with *U. impressa,* November 19.

Diaperis maculata var. **floridana** Blatch. This species is an uncommon one here, but is occasionally found beneath loose bark hibernating in the hammocks. It also hibernates beneath loose pine bark. April 27.

Boletotherus bifurcus Fab. Found occasionally on shelf fungi in the hammocks.

Adelina lecontei Horn. Numbers taken under bark of oak limbs in pile. Evidently not hibernating, but at work as larvæ, presumably of this species were found working with them. February 4.

Helops cisteloides Germ. Characteristic of rotten stumps and logs, both in piney woods and hammock, but is rather scarce. January 15–28.

CISTELIDÆ.

Hymenorus obscurus Say. One taken on oak foliage at night, May 2.

OEDEMERIDÆ.

Oxacis thoracica Fab. This species is found very abundantly on chinquepin during its whole blooming period. April 27–May 24.

MORDELLIDÆ.

Tomoxia lineella Lec. A specimen taken by beating oak, April 18.

ANTHICIDÆ.

Notoxus calcaratus Horn. Met with frequently on the foliage of oak, hickory and other trees. April 29.

MELOIDÆ.

Nemognatha piezata Fab. Very numerous at blooms of the bull thistle, May 26.

Epicauta marginata Fab. Taken on wild *Gerardia* plant, August 31.

Epicauta strigosa Gyll. Numbers of this meloid at blooms of a composite. September 25.

RHIPIPHORIDÆ.

Rhipiphorus octomaculatus Gerst. A single specimen taken. Members of this genus greatly resemble the tumbling flower beetles and the adults are occasionally met with in the blossoms of various plants. August 7.

Rhipiphorus cruentus Germ. A specimen was taken at chinquepin bloom, April 26.

CURCULIONIDÆ.

Attelabus analis Ill. The adults of this little reddish weevil made their appearance about March 20. On this date they were few in number and their work was just beginning on oak. By March 27 the adults were very numerous and their work could be noticed everywhere.

The adult weevil rolls up the end of the leaf into a little thimble-shaped roll, depositing its egg in one end. The larvæ upon hatching, feed upon the substance of their nest. Rolls of what is probably the same species were observed in April on the leaves of chinquepin.

Pterocolus ovatus Fab. Several taken from oak foliage, April 13–15.

Tachygonus lecontei Gyll. This curious little weevil has been beaten from oak and prickly ash foliage. April 18.

Pandeleteius hilaris Hbst. Abundant on oak foliage at hammock edge in April.

Anthonomus saturalis Lec. Numbers taken on hickory foliage, April 16. Also observed to be active at night running over the foliage.

Prionomerus calceatus Say. A specimen taken on oak foliage, April 5.

Centrinus albotectus Casey. An abundant species in blooms of dewberry and Crategus at hammock edge, March 1. Abundant on blooms of a composite in open fields, May 15.

Craponius inaequalis Say. Taken on hickory foliage, April 2; makes squeaking noise when handled.

Conotrachelus anaglypticus Say. A specimen was found on newly cut oak stump in hammock, March 8. Several beaten from buckeye at Hogtown Creek, March 5.

Calandra oryzæ Linn. This weevil is very abundant at blooms of chinquepin. April 28–May 24.

SCOLYTIDÆ.

Ips calligraphus Germ. This scolytid was found in large numbers with its galleries in the bark of a felled long-leaf pine; the tree had died within the last three months, August 3. On this date the majority were just emerging from the pupal stage, but larger numbers of full grown larvæ and pupæ were present.

DIPTERA.

CECIDOMYIIDÆ.

Cecidomyia brachynteroides O. S. A number of galls were collected on *Pinus palustris* December 2. The bases of the leaves are enlarged to form galls.

Dr. Felt, in a letter, writes that "this is a rather common type of gall upon pines, which has gone in years past, under the name of **C.** *brachynteroides* O. S. or *C. pinirigidæ* Pack., the first being associated with deformations on *Pinus inops* and the second occurring on *P. rigida*. It happens that insects have been reared from neither of these, consequently we are uncertain as to the actual identity of the gall maker, though rearings from a similar gall on the Western *P. radiata* produced a species very different from what has been supposed to be the cause of these swellings in the Eastern states. It is possible that one or more species may be responsible for these galls in the Eastern states, and under the conditions a definite determination is out of the question."

CULICIDÆ.

Psorophora ciliata Fab. Giant Mosquito or Gallinipper. This is our largest species of mosquito and is known nearly everywhere in Florida as the "Gallinipper." Although frequently found in velvet-bean fields adjacent to hammocks, near moist or wet areas, it is typical of low hammock. It is very persistent, even in open daylight and its bite very painful.

The following mosquitoes have been taken at Gainesville by Mr. U. C. Loftin ('13): **Culex quinquefasciatus, Anopheles quadrimaculatus, Anopheles crucians, Stegomyia calopus.**

ASILIDÆ.

Mallophora orcina Wied. This robber-fly is taken occasionally in hammocks. August 13. Very little is known of the breeding habits of the American species of robber-flies. Hubbard ('80, p. 262) saw a female of this Florida species bury its abdomen in the ground, where it deposited five or six eggs at a depth of half to two-thirds of an inch. The eggs hatched in a week.

Deromyia bilineata Loew. This is the most abundant asilid in the region. It has been taken in piney woods and hammock margin and is abundant in velvet-bean fields adjacent to hammocks. August 6–September 27.

BOMBYLIIDÆ.

Sparnipolius fulvus. This species is taken at the blooms of golden-rod and other flowers and is particularly abundant in May. May 9–October 18.

Systoechus solitus Walk. Taken in association with the preceding species and in about the same numbers.

SYRPHIDÆ.

Milesia virginiensis Drury. Numbers are often seen buzzing around old logs in damp hammocks in April and May. This is the largest and most striking syrphid in the region. Taken at wild cherry blossom, March 7. Hogtown Creek, May 21.

Eristalis vinetorum Fab. Taken at the blossoms of various plants but is uncommon. A specimen was taken at window light, May 26.

The larvæ of the genus **Eristalis** are of the long-tailed, filth-inhabiting type of syrphidæ, which live normally in sewage and putrid or stagnant water, (Metcalf '16, p. 218).

TACHINIDÆ.

Jurinea adjusta V. d. Wulp. Numbers of this very large hairy tachinid were taken at *Crategus* blooms, March 25. Common at chinquepin blooms, May 3.

Spallanzania hebes Fall. A number of specimens were taken at chinquepin blooms, May 23.

Archytas lateralis Macq. This was the most abundant parasite reared from *Malacosoma americana.* These large flies issued from pupæ April 13–14.

Achaetoneura schizuræ Towns. Numbers were reared from *Malacosoma americana* larvæ, April 13.

Frontina aletiæ Riley. A few specimens were reared from larvæ of the same host, April 13.

Plagiprospherysa parvipalpis V. d. W. Several specimens taken at chinquepin blooms, May 20.

Trichopoda pennipes Fab. This is a very common visitor to various flowers, as golden-rod, etc. It has been reared at Gainesville in large numbers from the pentatomid, *Nezara viridula,* an insect that is found abundantly in the hammocks. February and August 25.

SARCOPHAGIDÆ.

Sarcophaga opifera Coq. This species was reared from one of the bird grasshoppers, **Schistocerca alutacea,** October 28th. The percentage of parasitization is small, only one individual being parasitized, this one producing seven adult flies, out of fifteen of the grasshoppers collected in the field.

Sarcophaga helicis Towns. A large number of maggots emerged from a dead sphinx pupa, October 7. Pupated October 8, and the adults issued sometime later.

TABANIDÆ.

Chrysops vittatus var. **floridanus** Johnson. This fly is found in all hammocks, but is more abundant in piney woods. It occurs commonly from May to October, but is more abundant during the hot summer months.

As one walks into the shade of the woods, several of these flies will circle round one's head, frequently making sudden dashes at their victim. They are very persistent and annoying and their bite is painful.

Chrysops atropus O. S. A specimen taken flying around *Crategus* in bloom, March 8.

Tabanus mexicanus Linn. The males of this tabanid are found in plentiful numbers at chinquepin blooms, from April 30–June 1. Prof. Watson took a specimen in flatwoods, September 4.

Tabanus atratus Fab. This species is also found at chinquepin bloom, but is not as common there as the above species. It often attacks horses and cattle in the hammocks and is one of the most common forms here.

HYMENOPTERA.

TENTHREDINIDÆ.

Macrophya formosa Klug. A specimen taken at night on chinquepin leaf, April 24.

CYNIPIDÆ.

Amphibolips. This cynipid forms a small oak ball and is very abundant over the hammocks. Large numbers were issuing June 25. From one of these balls issued a huge number of small hymenopterous parasites, *Tetrastichus* sp. June 25.

Callirhytis batatoides Ashm. More or less round swellings on twigs. Large numbers were collected fresh December 2. Most of the adults issued January 25–31.

Dis holcaspis ficigera Ashm. Large numbers of this gall were collected on twigs of live oak, **Q. virginiana,** January 1. A number of adult flies and parasites issued January 25–31.

Andricus virens Ashm. These galls were abundant on underside of *Q. virginiana* leaves at edge of hammock, December 2. The adults issued for the most part early in February. A single specimen of the parasite, *Eupelmus auratus*, issued March 1.

ICHNEUMONIDÆ.

Exetastes Sp. A single specimen of this pretty blue hymenopteron was taken on oak, June 11.

Campoplex gelechiæ Ashm. This is a very efficient parasite of *Gelechia cercerisella* Chamb. Issued in abundant numbers the latter part of July from pupæ.

Mesostenus sp. A beautiful hymenopteron taken occasionally in hammocks. May 15.

EULOPIDÆ.

Sympiesis sp. Numbers of this little metallic-blue chalcid have been reared from pupæ of the serpentine leaf miner, *Phyllocnistis magnoliella*, both on *Magnolia grandiflora* and *M. galauca*. August 1–4.

Zagramosoma multilineata Ashm. A number of this queer chalcid have been reared from *Phyllocnistis magnoliella*, August 1–4.

Aphelinus mytilaspidis LeB. Numbers of this small lemon-yellow parasite were reared from the scale, *Chionaspis pinifoliæ* var. *heterophyllæ*. December 26.

Prospaltella sp. Reared from the same scale on pine in small numbers, December 26.

Coccophagus immaculatus Howard. Reared in numbers from *Toumayella parvicorne* Ckl. and *Toumayella turgida*. December 2–March 2.

ENCYRTIDÆ.

Eupelmus auratus Ashm. A specimen issued from a gall of *Andricus virens* on live oak, March 1.

Eupelmus mirabilis Walsh. Numbers have been reared from the eggs of the katydid, *Microcentrum rhombifolium*.

CHALCIDIDÆ.

Chalcis. A species that has been taken several times in the daytime asleep on the under surfaces of both *Magnolia grandiflora* and *Persea borbonia* leaves. December 10–24.

SCOLIIDÆ.

Elis subjens. Taken abundantly at chinquepin blooms during season.

EUMENIDÆ.

Eumenes fraternus Say. The adults are abundant at chinquepin blooms.

Monobia quadridens Linn. Very common at chinquepin blooms.

VESPIDÆ.

Polistes americanum Fab. This and many other *Polistes* are abundant at the blooms of flowers, especially the chinquepin.

Vespa carolina Dru. Three specimens were found hibernating under the loose bark of a large decayed oak in high hammock, January 25.

SPHECIDÆ.

Chlorion caeruleum Dru. This common dirt-dauber is abundant at chinquepin blooms, April 28–May 24. Taken April 29, with a very large spider in its clasp.

BEMBECIDÆ.

Bembidula quadrifasciata Say. Abundant at chinquepin blooms. April 28–May 24.

Bembex texana Cress. Also abundant at chinquepin blooms.

XYLOCOPIDÆ.

Xylocopa virginica Dru. This large carpenter bee is common at chinquepin and other flowers in May.

APIDÆ.

Psithyrus laboriosus Fab. Taken at chinquepin bloom, May 13.

Bombus pennsylvanicus DeG. Our largest species, although it varies considerable in size. Abundant on bull thistle plants at night and at flowers. March and April.

Apis mellifera Linn. This common honey bee is abundant everywhere at flowers at all seasons of the year.

LEPIDOPTERA.

NYMPHALIDÆ.

Anosia plexippus Linn. This species is not near so common here as in the more northern states. It is essentially an open field type, but is frequently taken along hammock edge and in open glades. Most abundant during November.

Pyrameis atalanta Linn. Another species that is scarce here, though abundant in the more northern states. Taken at hammock edge, March 5 and May 15.

Junonia coenia Hub. Rather common here, flying through the hammocks. A hymenopterous parasite was reared from a larva of this species April 19.

Basilarchia astyanax Fab. Seen occasionally flying in the hammocks. April.

Debis creola Skinner. This is an inhabitant of rather dense hammocks. April 14–29 and September 30.

Neonympha sosybius Fab. This is the most common wood nymph here and is very abundant in the hammocks from March to November.

Neonympha phocion Fab. This wood nymph is typical of flatwoods, but is found also in the hammocks. Hasn't as long a season as the above species.

LYCÆNIDÆ.

Feniseca tarquinius Fab. This is a very rare butterfly in this region. A specimen was taken in July flying along path in magnolia hammock. Another was taken by Prof. Watson in Catocala Glen, May 30. Larvæ are known to be predaceous on aphids.

PAPILIONIDÆ.

The following members of the genus **Papilio** are typical of hammock and are abundant usually from March to November: **P. cresphontes, troilus, palamedes, philenor, turnus** and **ajax.**

NYMPHALIDÆ.

Heliconius charitonius Linn. This is a representative of a large and conspicuous tropical family and is typical of hammock. Found most abundantly during August and September.

SATURNIDÆ.

Actias luna Linn. A freshly emerged moth was beaten from *Aesculus pavia* foliage towards evening in hammock, March 10. Numbers of fresh moths have been taken at lights during April. Prof. Watson took a moth which was not yet dry on a twig at Hogtown Creek, September 30. There is probably, therefore, at least two broods a year.

Telea polyphemus Cramer. Two larvæ of this species were taken, one nearly full grown and the other only an inch and a quarter in length, feeding on the foliage of white oak, December 3. Adult moths were taken at lights, January 22–28. Adult moths were rather common at lights during April and several young larvæ also observed on oak during the first part of April.

This would tend to show that there is an over-lapping of broods and there are at least two broods a year.

CERATOCAMPIDÆ.

Anisota rubicunda Fab. Full grown larvæ were present on maples on Station grounds, August 4. Larvæ were very abundant on the swamp maple at Lake Alice, October 1. Pupated October 7–8, and adults issued October 26–30.

AMATIDÆ (SYNTOMIDÆ).

Cosmosoma auge Linn. Taken at dusk at blooms of mint (?) species, hammock edge, August 13. A fresh specimen taken at lights, December 28.

Dahana atripennis Grote. Taken at chinquepin bloom, April 29. In magnolia hammock, May 18. April 29–November 14.

LITHOSIIDÆ.

Hypoprepia fucosa Hub. A specimen taken by beating oak foliage at edge of hammock, April 3. A rare moth here.

ARCTIIDÆ.

Estigmene congrua Walk. Abundant and just emerging in hammock undergrowth. March 10.

Ecpantheria deflorata var. **denudata** Slosson. Found a large pupa, together with cast skin beneath loose bark of a magnolia tree, March 2. A number of this, the largest of our wooly bears, were found in the hammocks during the first part of December; one was in a hollow tree trunk about middle way up when the trunk was broken into. One of the larvæ pupated about the first of December and the adult issued in the laboratory December 22.

The larva of this species when ready to pupate seems to crawl under any available shelter, such as Spanish moss, logs, beneath bark, etc. It is a typical hammock form.

NOCTUIDÆ.

Apatela impleta Walk. A cocoon was collected on hickory twig in hammock. The adult issued February 7. The larva feeds upon a great variety of deciduous trees and shrubs (Holland '05).

Apatela morula Grote (?). An adult issued February 26 from a cocoon taken from between loose bark of pine stump in hammock, February 19.

Hadena miseloides Guenee. A dirty-green larva was found inhabiting an old gall on oak, in the hammocks, December 5. The larva pupated during February, the adult issuing February 20. This is a rare moth here.

Autographa basigera Walk. A specimen taken near dusk at flower bloom, edge of hammock, August 13. An uncommon form here.

Autographa verruca Fab. Rather abundant at catnip blooms in burned piney woods, July 23 (Prof. Watson).

Scolecocampa liburna Geyer. Rotten-log Caterpillar. Larvæ of this species are common under the bark of fallen limbs and logs of many kinds in an early stage of decay. They honeycomb the sapwood, leaving the remainder hard though discolored. The excrement is quite characteristic, often indicating the approximate location of the larva. December–March.

After reaching maturity, they make loose cocoons composed of a few strands of silk, mixed with chips and the grass left in the burrow.

This is one of the species that invades the wood in the sapwood stage of decay and is often found associated with slugs, *Passalus cornutus*, and the **ant,** *Solenopsis* sp.

Spragueia onagrus Guenee. This pretty little moth is abundant at the blooms of chinquepin and various flowers from April 29–July 15.

The underwing moths make their appearance about the middle of May, but are most abundant during July. Catocala Glen is especially rich in these forms and a number have been taken at Hogtown Creek.

Catocala epione Drury. Taken by Prof. Watson in Catocala Glen, May 30.

Catocala sappho Strecker. Taken by Prof. Watson in Catocala Glen, May 30.

Catocala ultronia var. **celia** Edw. A specimen was taken in Catocala Glen as early as April 15th by Prof. Watson. One of our most common underwings.

Catocala lacrymosa Guenee. A specimen taken June 29.

Anticarsia gemmatilis Hub. The adults of this species have been taken occasionally in hammocks and also in flatwoods, October 29. The larvæ do very serious damage to velvet-bean plants every year.

NOTODONTIDÆ.

Melalopha inclusa Hub. This species is recorded as feeding on species of *Populus*. The larvæ were abundant in their webs on willow, October 29, at edge of cypress swamp; flatwoods east of town. Also abundant on willow at edge of stream by road crossing the University sewer. They pupated shortly afterwards and the first moths issued in the laboratory about February 15.

LASIOCAMPIDÆ.

Tolype minta Dyar. A freshly emerged pair were taken on bark of *Pinus palustris* tree, February 10. There is a great difference in the size of the sexes. A large batch of closely scattered eggs covered with hairy material was deposited February 11. Eggs started hatching February 27; all hatched by March 3. There was a cocoon on the side of the tree also.

A slightly worn adult was taken on side of *Pinus palustris* tree in low hammock, December 4.

Malacosoma americana Fab. This species has only one brood a year in Florida and winters over in the egg stage.

Eggs began to hatch in the laboratory January 27; out of doors January 29. The larvæ began to spin their cocoons about March 23. The adult moths issued in about two weeks. They then mate and deposit their egg masses on the wild plum and wild cherry, their favorite food plants.

This insect is very heavily parasitized by a number of dipterous parasites, *Archytas lateralis*, *Achaetoneura schizuræ*, and *Frontina aletiæ* Riley having been reared.

GEOMETRIDÆ.

Dyspteris abortivaria H. & S. This little green moth is typically a hammock insect. Beaten from buckeye foliage March 9.

Euchlaena amoenaria Guenee. Is rather common in hammock, August 1–September 8.

Macaria praetomata Haw. Abundant at Hogtown Creek, March 4, (J. R. Watson).

Catopyrrha near **sphaeromacaria** Harv. These moth were abundant among grass and blackberry bushes near banks of Hogtown Creek, April 11.

PSYCHIDÆ.

Thyridopteryx ephemeraeformis Haw. This common bag-worm is found on the foliage of various trees and shrubs in the hammocks.

COCHLIDIIDÆ.

Sibine stimulea Clms. The Saddle-back. Feeds on the foliage of various trees. Has been taken feeding on *Ostrya virginica*, holly, and the red maple, December 2–4.

MEGALOPYGIDÆ.

Megalopyge opercularis A. & S. The larvæ of this species are seldom seen, but the cocoons are numerous on the twigs of oak, wild plum and other trees and shrubs.

PYRALIDÆ.

Melitera prodenialis Walk. Larvæ of this species were found eating prickly pear in piney woods at hammock edge, March 1.

Pantagrapha limnata G. & R. Basswood Leaf-roller. Numbers of these caterpillars were found on basswood in the hammock July 13. Some of the adults had emerged already on this date. A number of

rolled leaves were examined, the majority containing only a single larva, while others contained as many as three. The pupal stage averaged eleven days in length. A few larvæ were present on July 31. The larvæ first appear during early part of April.

Hymenopterous parasites of two species were reared in abundance from the larvæ. For notes on larvæ see Fernald ('84, p. 26-27).

TORTRICIDÆ.

Stenoma humilis Zell. Larvæ were found in abundance on oak foliage during June. An adult issued June 26. Several undetermined hymenopterous parasites have been reared.

Arogalea cristifaciella Chamb. A few larvæ of this leaf-tyer were collected on oak at hammock edge, April 13. Larvæ are very pretty and small and greenish, with purplish-black stripes across. One of these pupated April 24 and the adult issued May 3. The larvæ are not abundant.

GELECHIIDÆ.

Gelechia cercerisella Chamb. Red Bud Leaf-folder. The larvæ of this species begin their work early in April. They fold the two edges of the leaf together, holding it together with a few strands of silk. The larvæ live inside, eating out the epidermis; as many as six very young larvæ to a leaf, but usually only one. Larvæ were very abundant June 25, in all parts of the hammocks.

An efficient parasite of this leaf-folder is *Campoplex gelechiæ,* which issued in abundant numbers from pupæ during July.

TINEIDÆ.

Ornix geminatella Pack. This is not a very abundant insect here. The larvæ first make their appearance the latter part of February, making blotch mines in wild cherry leaves. A small parasite has been reared from this species. Adults have issued as early as March 3.

Heliodines sp. (Near or **H. bella** Wkm.) Several specimens of this pretty orange and black micro-lepidopteron were taken at chinquepin blooms May 21.

Phyllonorycter lucetiella Clem. A number of blotch mines containing pupæ were collected on linden, May 15. Small silverish moths issued sometime later.

Mompha eloisella Clem. A specimen taken resting on linden leaf, April 20.

Phyllocnistis vitifoliella Chamb. This is a serpentine miner in wild grape leaves. Mines were very plentiful July 16. From a pupa collected in July 16 issued a minute silverish moth July 18.

Phyllocnistis magnoliella Chamb. This is a serpentine miner on the leaves of the sweet bay, *Magnolia glauca.* Upon hatching, the larva begins making its mine circling around three or four times and then begins to wind its mine serpentine-like all over the leaf, finally ending at the edge of the leaf, drawing it up into a little pucker to form its pupal chamber; here the larva changes to a yellowish-brown pupa. These mines, on leaves containing a number, not infrequently cross each

other. The pupal chambers are not confined to the edges of the leaves, but are found to a much less extent in other parts. The leaves gradually draw up, wither, and die from the effect of this.

This insect was first observed by the writer at Gainesville on July 15. On this date nearly every leaf of the sweet bay examined contained one or more mines, and nearly all being in the pupal stage. Numbers of the adults issued from July 17–21. There are a number of broods which overlap each other. Fresh mines were abundant up until August 9 and from then on only a few fresh mines were observed. Several adults issued from material November 2–3. The insect in all probability passes the winter in the pupal stage in old leaves.

Numbers of the chalcid parasites, *Zagrammosoma multilineata* and *Sympiesis* sp., were reared.

The adults have been reared from mines on *Magnolia grandiflora* and sweet bay, *Magnolia glauca.* Mines of what is probably the same species have been observed in the red bay, *Persea borbonia.*

Homaledra sabaella Chamb. The writer has found larvæ of this species working on saw-palmetto (Serenoa serrulata), and the palms *Phoenix canariensis* and *Washingtonia robusta.* They can hardly be said to be leaf-miners, as they feed upon the upper surface of the leaf, destroying the skin as well as the fleshy part of the leaf. Their unsightly work is particularly noticeable from January to March.

An undetermined hymenopterous parasite was reared from a pupa February 19.

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THE GENUS TROMBICULA BERLESE, IN AMERICA AND THE ORIENT.

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The recent demonstration that the well-known "kedani," or chigger mite of Japan, is the active agent in the transmission of a deadly human disease ("tsutsugamushi" disease, or flood fever) has brought the whole chigger mite group under the suspicion of being one of possibly great importance in the carrying of disease among man and domesticated animals. The further rearing of the adults of this chigger in 1916 by two groups of Japanese workers, and proving them to be Trombiculas has paved the way for an investigation into the taxonomy and biology of all the species of this genus. Such an investigation is now of prime importance, for we may well presume that the other species of the group are not so vastly different in their habits from those of the deadly "kedani."

During the summer of 1919 the writer had the good fortune to meet Dr. M. Miyajima and to study with him some of the different members of the genus. At first it appeared to us that our only described species, *Trombicula splendens* Ewing, was a synonym of the Japanese form, the adult of the "kedani," which Dr. Miyajima holds to be *Trombicula coarctata* Berlese. A more careful study of the type of *T. splendens*, as well as the paratypes in the American Museum of Natural History, has shown that the two species are quite distinct, as will be made evident in this paper. While Dr. Miyajima was yet in this country another Trombicula species was discovered by the writer near Washington, D. C. This species is described in the present paper for the first time.

When examined superficially all the known species of the genus *Trombicula* appear remarkably alike. They vary in length from 1 to 1.6 mm. in most cases and are always well clothed with strongly pectinate setae. The color varies from that of human flesh to a scarlet vermilion, but usually would be called a reddish orange. Their proportions are almost identical; legs moderate, body stout, cephalothorax small, the abdomen deeply constricted; this latter character at once distinguishing them from all other Trombidiidæ.

A more careful examination of the microscopical structures reveals to us, however, that the species can be easily separated. For this purpose Berlese has already used; size, the presence or absence of the eyes, variations in the relative lengths of the front tibiæ and tarsi, the ratio between the length and breadth of the front tarsi, and to a limited extent the nature of the body setæ and a few other structures. Of these characters the selection of size appears to be rather unfortunate, as there is not only a remarkable uniformity in size among some of the adults, but the nymphs, which are smaller than the adults, are so easily confused with the latter. The use of the ratio existing between the lengths of the front tibiæ and tarsi is good and in this paper will be expressed by taking the length of the tibia as unity. The following characters should be added to those given by Berlese as being of much importance in specific diagnosis: The structure and shape of the crista, especially the expanded portion, or pseudostigmatic area; the position, size and structure of the sense hairs, or pseudostigmatic organs; the structure of the body setæ, especially should it be noticed whether the barbs extend to the tip or not, their relative length when present at the tip, and also the thickness of the seta at its tip.

THE "AKAMUSHI" OR "KEDANI" MITE.

Through the generosity of Dr. Miyajima, the writer has examined a good series of the adults of the "kedani." In general appearances these specimens are almost exactly like our Trombiculas. However, when we examine those characters that alone are of specific importance, we find that the Japanese Trombicula is quite distinct from both our species. A description of the "kedani" adult follows in which only those characters that are of specific importance are given.

Trombicula coarctata Berlese. Color of alcoholic specimens almost white, but live ones are "light reddish ochre" (Miyajima and Okumura). Body well clothed with strongly pectinate, whitish setæ, showing a tendency to be grouped in longitudinal rows. Cephalothorax triangular in outline. Eyes wanting, also vestiges wanting. Crista extending for the whole length of cephalothorax; carina straight and extending from the anterior end of crista into the pseudostigmatic area; posterior lobes of this area more or less angulate and situated directly behind the pseudostigmatic pores. Pseudostigmatic organs, or sense hairs, delicate, about as long as the crista and each provided with a few delicate barbs on the distal half, the number of barbs present

being variable. Palpi each with four inner tibial spines, the longest of which is equal to about half the length of the claw. Thumb of palpus not surpassing the claw. Abdomen with the usual constriction. Setæ of abdomen much longer on the posterior margin than on the shoulders. Each seta is situated on a pedicel bearing disc, is strongly pectinate and usually stoutest at its tip, where the barbs are somewhat less conspicuous. Legs rather stout, the anterior pair much the longest and largest, the posterior pair reaching the tip of the abdomen. Tarsus I is one and sixty-one hundredths times as long as tibia I and is much thicker dorso-ventrally than laterally. Tarsus IV about one and a fourth times as long as tibia and with the outer claw slightly smaller and more strongly curved than the inner. Length usually from 1.00 mm. to 1.10 mm., but varies considerably; breadth from 0.50 mm. to about 0.65 mm.

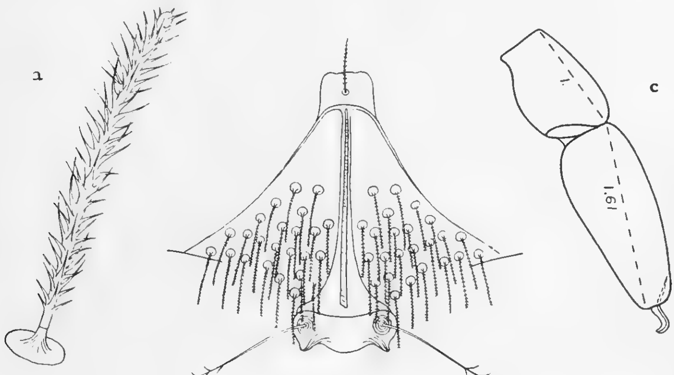

Fig. 1. *Trombicula coarctata* Berlese; *a*, seta from dorsum of abdomen; × 900; *b*, dorsal view of cephalothorax, × 375; *c*, last two segments of right front leg, side view, × 125.

Several individuals received from Dr. Miyajima from Japan.

This species strongly resembles *T. splendens* Ewing, when examined superficially, but in reality is quite distinct. It is a blind species, whereas *T. splendens* has eyes, which, however, are not strongly developed and are easily overlooked. The posterior lobes of the pseudostigmatic area in the Japanese species are angulate and situated directly behind the pseudostigmata. In *T. splendens* these are evenly rounded and are situated approximate at the median line. In *T. coarctata* the pseudostigmatic organs arise from the pseudostigmata and are distinctly pectinate; in *T. splendens* these structures arise *inside* the pseudostigmata and are either simple or but very slightly pectinate. The body setæ of the Japanese species are

frequently thickened at the tips. This is not true of *T. splendens*. There are several other minor differences between the two species, such as a difference in the tarsus-tibia ratio in leg I.

More is known concerning the biology and life history of this chigger mite than any other, due to the very extensive researches of several Japanese workers, yet much remains to be learned concerning it. Dr. Miyajima holds that it is a vegetable feeder, and Miyajima and Okumura state: "In nature, both the nymph and the adult seem to live on the juice of plants, *e. g.*, reed (*Imperata arundinacea Cyr.*), daisy (*Artenisia vulgaris* L.), etc." If this species is a true vegetable feeder in the adult state, it is entirely different in this respect from all other species of Trombidiidæ, whose feeding habits are known.

T. coarcta is found in many places in Japan and doubtless occurs in several other oriental countries. Berlese described the species from South America, where it is known to occur in Paraguay and Argentine Republic. Indications at present are that it has a wide distribution in subtropical and temperate countries.

THE GENUS TROMBICULA IN THE EAST INDIES.

The East Indies have long had a notorious reputation for their chiggers. Many are the tales that various travelers have related in regard to their attacks. As early as 1869 Alfred Russell Wallace wrote of them, saying they were "worse than mosquitoes, ants and every other pest, * * * ." It was not, however, until 1912 that we had any extensive scientific description of the chigger larvæ of these islands. In this year appeared Oudeman's extended work on "Die bis jetzt bekannten Larven von Trombidiidæ und Erythraeidæ," in which he describes and speaks at length of two species known to attack man in these islands. The same year appeared the extended work of the eminent Italian entomologist, Antonio Berlese, on the "Trombidiidæ." In this work Berlese gives descriptions of two Trombiculas from Java; one as *T. mediocris* and one as *T. minor*. According to Berlese these two species are closely related, yet he held them to be distinct, largely because *minor* was considerably smaller, had shorter abdominal setæ and the anterior tarsi were more conical in shape.

After rearing the adult of the "kedani" mite and demonstrating the nymphal characters in that species, Dr. Miyajima came to the conclusion that *T. minor* was only a nymph of *T. mediocris.* A careful study of the nymphal characters as given by Drs. Miyajima and Okumura certainly lends weight to Miyajima's opinion. Of special importance is their demonstration that the "kedani" nymph has only two palpal spurs, while in the adult there are four. If we grant the synonymy of these two species, the name *minor* has precedence over *mediocris* because of priority. This is unfortunate, as *mediocris* is one of the largest species of the genus, yet according to the application of the priority rule, loses this name to become *minor.*

T. minor (*mediocris*) Berlese is found outside the East Indies as was shown by Drs. Kitashima and Miyajima, who received material from Formosa, sent by Herrn Hatori. In their extended paper, "Studien ueber die Tsutsugamushi, Krankheit," they give an excellent figure of *minor* (*mediocris*) and make comparisons between this species and the adult of the "kedani" mite; held to be *coarctata.*

In the orient then we have, as far as is known, two *Trombicula* species, *T. coarctata* and *T. minor* (*mediocris*). One of these is known at present in the orient only from Japan, the other from Java and Formosa. It may be added that *T. minor* has the body clothed with shorter, and *colored* setæ, which are of about equal length over all of the dorsal part of the abdomen, while *T. coarctata* has longer and *colorless* hairs on the dorsum of the abdomen, and those around the posterior margin are much longer than those on the shoulders.

OUR TROMBICULAS.

As in the orient, so in the United States we have two Trombiculas. One of these was described by the writer as *T. splendens* in 1913, from Wisconsin, and the other was discovered during the summer of 1919 in Virginia and Maryland. *T. splendens* resembles *T. coarctata* in having the long, colorless body setæ, which are much longer on the posterior margin than on the shoulders, while our other species resembles Berlese's *minor* in having the shorter, colored and almost uniform body setæ. The former species is here described:

Trombicula splendens Ewing. As indicated in its specific name, this species has a splendid appearance, which is given to it by its wonderful coat of feathery hairs. It is more beautiful than our other species, yet it can hardly be said to be more attractive than the Japanese "kedani" adult. The cephalothorax is triangular in outline, with the crista extending for its entire length. Carina of crista much reduced and chiefly confined to the pseudostigmatic area, which is triangular in general outline. Posterior lobes of speudostigmatic area evenly rounded behind and situated approximate to the median line. Pseudostigmatic hairs, or sense setæ, simple or with exceedingly inconspicuous barbs and situated inside of pseudostigmata and, therefore, not arising from them. Eyes just lateral and posterior to pseudostigmata. They are not well developed, the corneas being thin and inconspicuous.

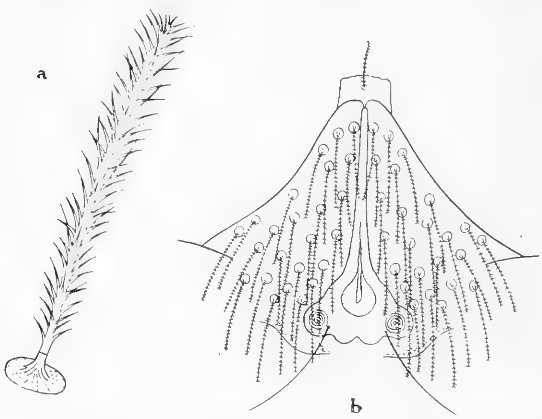

Fig. 2. *Trombicula splendens* Ewing; *a,* seta from dorsum of abdomen, × 900; *b,* dorsal view of cephalothorax, × 375; *c,* last two segments of front leg, side view, × 125.

Palpi longer than first two segments of leg I; thumbs cylindrical and not exceeding the palpal claw. Abdomen strongly constricted as usual and well clothed with long and strongly pectinate setæ. Each seta arises from its pedicellate disc and is provided with barbs for its entire length; at its tip the barbs somewhat smaller; tip never thickened. First pair of legs as long as body, excluding the beak; tarsus somewhat cone-shaped, one and forty hundredths times as long as tibia. Second and third pair of legs about two-thirds as long as first pair. Last pair of legs just reaching the tip of the abdomen. Length of body, including beak, about 1.00 mm.; width about 0.56 mm.

From Portage, Wisconsin, September 2, 1909; on under side of stones on ground; by the writer.

About half a dozen adults of this species were taken. The type is in the writer's private collection, but the paratypes are deposited in the American Museum of Natural History, New

York City. The three drawings here given are all made from the type.

This Trombicula is quite distinct from *T. coarctata*, as has already been pointed out. It is at once distinguished from the species found in Maryland and Virginia by having only vestigial eyes, the pseudostigmatic organs arising inside of the pseudostigmata, and by having the body setæ much longer and colorless. Little is known of its habits. Since all the specimens were found above the soil and the species has not completely lost its eyes, it may be inferred that it is not subterranean in habits.

Trombicula cinnabaris n. sp. Color of live adults scarlet vermilion, or cinnabar. Cephalothorax triangular and with the crista extending for its entire length. Carina of crista extending from the anterior end of the latter as a straight ridge to about the middle of the triangular, pseudostigmatic area. Posterior lobes of pseudostigmatic area evenly rounded and near the median line. Pseudostigmatic organs arising from pseudostigmata and provided with a few minute barbs on their posterior margins near their tips. Eyes well developed, very near the pseudostigmata and with thick and strongly curved corneas. Palpi armed with three tibial spurs, the longest of which is less than half as long as the palpal claw; thumb of palpus not swollen and not surpassing the palpal claw. Cheliceræ with lower chela sharp and provided with about two dozen backwardly directed teeth; upper chela represented by a chitinous tubercle-like knob. Abdomen clothed with the usual setæ, which are but slightly, if at all, longer on the posterior border than on the shoulders, and have the barbs smaller at the somewhat tapering tip. Legs about as usual, the first pair being much the largest and longest. The tarsi of this pair are one and forty-seven hundredths times as long as the tibiæ. Posterior legs reaching to the tip of abdomen. Length of medium-sized specimen, 0.92 mm.; width, 0.52 mm.

From East Falls Church, Virginia; summer of 1919; by the writer. From North Beach, Maryland; summer of 1919; by the writer. Found both in the soil and on the surface of soil under dead leaves and bits of decaying vegetable matter.

Described chiefly from the type which was taken at East Falls Church, Virginia, August 21, 1919, from soil of a blackberry patch which was heavily infested with chiggers. This, our Eastern Trombicula, is most closely related to *T. minor* (*mediocris*) Berlese. It is differentiated from Berlese's species by having only three spines on the palpus instead of four and in being considerably smaller.

The adults of *T. cinnabaris* probably spend most of their time on the surface of the ground, where they go about under

the dead leaves and grass in search of food. They appear to feed chiefly upon juices of small arthropods, either recently killed or in a quiescent instar. One individual was kept for many weeks in the finest of condition in a small vial with this kind of a diet. This individual was never observed to enter

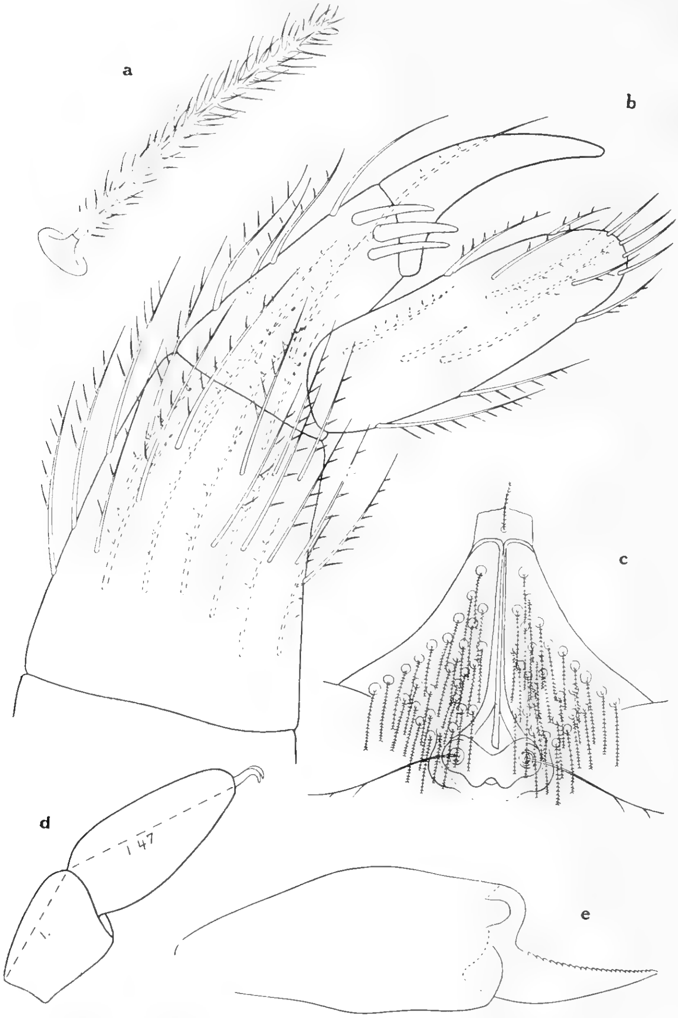

Fig. 3. *Trombicula cinnabaris* n. sp.; *a*, seta from dorsum of abdomen, × 900; *b*, last three segments of left palpus from inside, × 900; *c*, dorsal view of cephalothorax, × 375; *d*, last two segments of right front leg, side view, × 125; *e*, left chelicera from inside, × 800.

or burrow into the sand provided for it in the breeding vial. Individuals thrive only with a very moist atmosphere, even saturation is not injurious to them. Their coats of feathery setæ keep their bodies dry. When placed in water they come rapidly to the top and can walk about over the surface.

In order to enable different workers to determine species of the genus and in order to call attention to certain characters which alone are of value in separating the different species, a key to all those known up to the present is here given.

KEY TO THE SPECIES OF THE GENUS TROMBICULA BERLESE.

A. Eyes present and well developed; setæ of body but slightly longer on the posterior margin than on the shoulders, and colored.
  B. Palpus armed with four spines on the inner side of tibia; adults about 1.5 mm. in length.................................... *T. minor* Berlese
  BB. Palpus armed with only three spines on the inner side of tibia; adults not over 1.0 mm. in length.......................... *T. cinnabaris* n. sp.
AA. Eyes vestigial or absent; setæ of body considerably longer on the posterior margin than on the shoulders.
  B. Anterior tarsi much less the three times as long as broad; palpus armed with four accessory spines.
    C. Posterior lobes of pseudostigmatic area larger, rounded and not behind the pseudostigmata; pseudostigmatic hairs arising inside of pseudostigmata; body hairs thinner at their tips than elsewhere, *T. splendens* Ewing
    CC. Posterior lobes of pseudostigmatic area smaller, more or less angulate and immediately behind the pseudostigmata; pseudostigmatic hairs arising from the bottoms of pseudostigmata; body hairs not thinner at their tips.......................... *T. coarctata* Berlese
  BB. Anterior tarsi much more than three times as long as broad; palpus armed with three accessory spines.
    C. Total length much more than 1.5 mm.; anterior tarsus over four times as long as broad......................... *T. formicarum* Berlese
    CC. Total length less than 1.5 mm.; anterior tarsus considerably less than four times as long as broad................ *T. canestrinii* Buffa

SYNONYMY.

The suggestion of the synonymy of *T. mediocris* with *T. minor* is received with some hesitancy, and as here given is based upon the study of the nymphal characters of the "kedani" by various Japanese workers. More data is needed in regard to the life history of *minor* before the question of synonymy can be settled with certainty.

Trombicula minor Berlese.

1905. *Trombicula minor* Berlese. Acari Nuovi. Redia, Vol. II, pp. 155-156, Tav. XV, Figs. 4 and 4a.
1912. *Trombicula mediocris* Berlese. Trombidiidæ. Redia, Vol. VIII, pp. 93-94, Fig. 43.
1912. *Trombicula minor* Berlese. Trombidiidæ. Redia, Vol. VIII, pp. 94-95, Fig. 44.
1918. *Trombicula mediocris* Berlese. Kitashima and Miyajima: Studien Ueber die Tsutsugamushi-krankheit. Kitasato Archiv. Exp. Med., Vol. II, pp. 190-191, Taf. VIII, Fig. 2.

Trombicula splendens Ewing.

1913. *Trombicula splendens* Ewing. New Acarina, Part I. Bul. Am. Mus. Nat. Hist., pp. 113-114, Pl. VII, Fig. 5.

Trombicula coarctata (Berlese).

1888. *Trombidium coarctatum* Berlese. Acari Austroamericani. Bul. della Soc. Ent. ital. Anno. XX, p. 9, Tab. V, Fig. 5.
1901. *Trombidium coarctatum* Berlese. Leonardi: Acari sud-americani. Zool. Anz., Bd. XXV, p. 17.
1912. *Trombicula coarctata* Berlese. Trombidiidæ. Redia, Vol. VIII, pp. 91-92, Fig. 42.
1913. *Trombidium akamushi* Brumpt. Precis de Parasitologie. 2. edition. Paris.
1915. *Microtrombidium akamushi* Brumpt. Hirst: On the Tsutsugamushi (*Microtrombidium akamushi,* Brumpt), Carrier of Japanese River-fever. Jour. Econ. Biol., Vol. X, p. 79 and Fig.
1915. *Microtrombidium brumpti* Hirst. Jour. Econ. Biol., Vol. X, p. 79 and Fig.
1916. *Leptotrombidium akamushi* (Brumpt). Nagayo, Miyagawa, Mitamura, and Imamura: Ueber die Imago und die Eier von Tsutsugamushi (Milbe). Ijishimbun, No. 958, Sept. 1916. (Nipp.). (From reference in foot-note by Miyajima and Okumura).
1917. *Leptus akamushi* (Brumpt). Miyajima and Okumura. On the Life Cycle of the "Akamushi," Carrier of Nippon River Fever. Kitasato Archi of Exp. Med., Vol. I, p. 13, Fig. 1 and Pls. I-III.
1918. *Trombicula coarctata* Berlese. Kitashima and Miyajima: Studien ueber die Tsutsugamushi—krankheit. Kitasato Arch. Exp. Med., Vol. II, Nos. 2-3. Figures as follows: In text, 1-3; Taf. VI, all Figures; Taf. VII, Fig. 1; Taf. VIII, Fig. 1.

Trombicula formicarum Berlese.

1910. *Trombicula formicarum* Berlese. Brevi Diagnosi di Generi e Specie Nuovi di Acari. Redia, Vol. VI, p. 369.
1912. *Trombicula formicarum* Berlese. Trombidiidæ. Redia, Vol. VIII, pp. 90-91, Fig. 41.

Trombicula canestrinii (Buffa).

1899. *Trombidium canestrinii* Buffa. Trombidium canestrinii, n. sp. Atti Soc. Vento Trent. di Sc. Nat. See Canestriniis Prospet. Acarof. Ital., Vol. VIII, pp. 975-977, Pl. C.
1912. *Trombicula canestrinii* (Buffa). Berlese: Trombidiidæ, Redia, Vol. VIII, pp. 88–90, Fig. 40.

SOME STUDIES ON THE INFLUENCE OF ENVIRONMENTAL FACTORS ON THE HATCHING OF THE EGGS OF APHIS AVENÆ FABRICIUS AND APHIS POMI DeGEER.*

By Alvah Peterson.

INTRODUCTION.

The eggs of *Aphis avenæ* Fabricius[1] and *Aphis pomi* DeGeer have two distinct layers in the egg shell (Figures 1 to 4). The outer layer, when the eggs are first deposited, is transparent, soft and glutinous, but it soon hardens upon exposure to weather conditions and becomes semi-transparent, toughened, dry and decidedly impervious to water. The inner layer is a soft, elastic, black membrane and decidedly pervious to water.

The outer layer usually splits (Figures 2 and 3) along the dorso-mesal line a number of days before the nymph emerges. The above structure and splitting of the outer layer is also characteristic of the eggs of other species of plant lice; a species of *Lachnus*, which deposits its eggs on the needles of whitepine, another aphid which deposits its eggs about the buds of weeping willow and at least one species of aphid which deposits its eggs in ant nests. I am indebted to Mr. J. L. King for furnishing me with eggs from an ant nest. The time and percentage of the splitting of the outer layer and the hatching is dependent upon environmental conditions, particularly temperature and moisture. The outer layer of the eggs of *A. avenæ* may start to split in February (February 10, 1919), while the splitting of the eggs of *A. pomi* usually does not start until March, (March 3, 1919). The eggs of *A. avenæ* usually hatch rapidly the last week in March and the eggs of *A. pomi* usually hatch rapidly somewhere between April 5 to 15th. The above observations are true for New Brunswick, N. J. For further information on the time and percentage of splitting and hatching, see Tables 4 and 5 and references.

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*Contribution from the Entomological Laboratory of Rutgers College, State University of New Jersey, New Brunswick, N. J.

[1]*Aphis avenæ* Fabricius is *Rhopalosiphum prunifoliæ* Fitch according to A. C. Baker and W. F. Turner.

EVAPORATION.

The splitting of the outer coat of the egg and the percentage of hatch of the eggs of *A. avenæ* and *A. pomi* are influenced considerably by evaporating factors. These factors in a natural environment are moisture, temperature and wind velocity. This paper takes into consideration the response of the eggs to moisture and temperature.

The two layers of the egg are decidedly different in their pervious nature. To determine the relative permeability of the two layers of the eggs of *A. avenæ* a simple experiment was conducted in 1917; the outer semi-transparent tough layer was removed from fifteen normal eggs on April 5 and the skinned eggs were placed in a covered Syracuse watch glass. Fifteen normal eggs were placed in the same vessel. The skinned eggs shriveled completely inside of 24 hours and none hatched, while 6 of the 15 normal eggs hatched in 4 days. The above experiment was repeated with the eggs of *A. pomi* and the results were approximately the same. These experiments show that outer layer on the egg prevents evaporation under ordinary conditions, while the inner pigmented layer is of little use in preventing evaporation. If this is true then one may conclude that eggs with split outer coats are more susceptible to evaporating factors than normal eggs with whole outer layers.

MOISTURE.

The influence of moisture on the eggs of *A. avenæ* and *A. pomi* was determined by incubator experiments with controlled moistures and temperatures; by other experiments where the eggs were placed in moist chambers under ordinary conditions indoors and outdoors and by observing the percentage of splitting and hatching of the eggs of *A. avenæ* for four variable seasons, 1917 to 1920, and comparing these observations with the weather conditions for the respective years.

The controlled moisture and temperature experiments were conducted in 1917 and 1920 in the incubators and moisture control apparatus used by Dr. T. J. Headlee in his investigations on the bean weevil; the writer wishes to express his appreciation for the privilege of using this efficient equipment. The incubators were fitted with one to three moisture control systems. Each system (Figure 6) was composed of two air dryers, a

moisture generator, one or more air chambers and a pump. The moisture generators and the air chambers were located in the incubators and kept at a constant temperature; 80° F. in 1917 and 70–72° F. in 1920. The air was taken from the room and first passed through the two tubes of sulfuric acid (Specific Gravity 1.84), which removed all of the water. The dry air was then drawn through concentrated salt solutions and a constant amount of water was absorbed by the dry air. The moisture content of dry air after it passes through concentrated salt solutions varies with different salts, but the same salt always gives up a definite amount of moisture. This was determined for each salt a number of times and each test showed less than 0.5 per cent variation in the water present. The air goes from the moisture generator to the air chambers, where the numerous eggs were located on short twigs. Small twigs bearing numerous eggs were selected in order that the moisture arising from the freshly cut twigs would have as little influence as possible on the moisture content of the air. It is believed that the small amount of moisture arising from the twigs had very little effect; if the moisture in the twigs effects the air in the chambers the effect is of short duration, for it was noted that the twigs in the chambers having low moisture content dried and shriveled in two or three days, while the eggs usually required ten to fourteen days to hatch after they are placed in the air chambers. The air was drawn from the air chambers by a small pump, which was operated by flowing water.

Table 1 shows the influence of various constant percentages of moisture on the eggs of *A. avenæ* and *A. pomi*. The dates at the top of the columns indicate the day the experiments were started. The percentage of hatch varies with the moisture content; the greatest percentages of hatch occur in airs possessing a large amount of moisture, while low percentages of hatch occur in airs possessing small amounts of moisture and usually no hatch in dry air. Some of the eggs in the above experiments had split their outer coats when the experiments were started. In the dryer airs these eggs shriveled rapidly and failed to hatch.

In 1917 eggs of *A. pomi* were placed in the incubators early in March, but this is too early for this species. For some unknown reason one cannot get a normal percentage of hatch of the eggs

of *A. pomi* if they are brought into warm room temperatures earlier than 20 to 30 days before the outdoor hatching period. Even though the eggs failed to hatch, their rate of shrivel was most rapid in the dry air and air of low moisture content.

Besides the incubator experiments, several series of moisture experiments were conducted indoors and outdoors with the eggs of *A. avenæ* and *A. pomi* during 1919 and 1920. In each of these series approximately 2000 eggs were collected and divided into four groups (A, B, C and D) with 500 eggs in each. These were placed under four different conditions; two lots (A and B) were kept indoors (greenhouse or laboratory) in

TABLE I.

Incubator experiments showing the effect of variations in moisture on the hatch of the eggs of *A. avenæ* and *A. pomi,* 1917 and 1920. Constant temperature 80° F. 1917 and 70–72° F, 1920.

No.	Percentage of moisture	Chemical used to generate moisture	Percentage of hatch, *A. pomi* April 6, 17	Percentage of hatch, *A. pomi* March 20, 20	Percentage of hatch, *A avenæ* March 25, 17
1	0–0.5	H_2So_4	2	0	4
2	25.9	$CaCl_2$	0	12	12
3	45.7	$Cu(NO_3)_2$	—	18–20	—
4	56.1	NaBr	—	30	—
4	73.4	NaCl	20	43–45	20
6	80.0	$NaNO_3$	—	55	—
7	100	H_2O	46	*	36
Average Number of eggs in each trial........			100–125	500–600	25–50

* Killed by fungi.

a temperature of 60–75° F. Lot A was placed in a moist chamber which registered 90 per cent moisture or better, while lot B was exposed to the usual indoor moisture, which was somewhere between 35 to 50 per cent. The other lots (C and D) were placed outdoors; lot C in a moist chamber which registered 75 per cent moisture or better and lot D subjected to the natural outdoor environment during the two seasons.

Table 2 shows the results of these experiments. In each series the eggs in lots A and C, which were located in moist chambers, showed a greater percentage of hatch than the eggs in series B and D, which were exposed to the normal indoor or

outdoor environment. In other words, air of high moisture content, as in the moist chambers, is more favorable for hatching than the normal indoor or outdoor air having a lower moisture content.

In Table 2 it will be noted that the percentage of hatched eggs of *A. avenæ* brought into the laboratory on February 11, 1919, is very low. This experiment and others of a similar nature show that the eggs of this species usually will not give a normal percentage of hatch when they are brought into the laboratory too early in the season. In this respect

TABLE II.

Percentage of hatch of the eggs of *A. avenæ* and *A. pomi* under different temperatures and moisture conditions in 1919 and 1920, at New Brunswick, N. J. 500 eggs in each lot.

Series	Environment	*A. avenæ* Expt. started Feb. 11, 19	*A. avenæ* Expt. started Feb. 27, 19	*A. avenæ* Expt. started March 10, 20	*A. pomi* Expt. started March 9, 20
A	Indoors Moist chamber, 75–95% Temperature, 60–75° F.	7.6	66	50+	55
B	Indoors Average moisture, 35–50% Temperature, 60–75° F.	1.5	30	27	10
C	Out-of-doors Moist chamber, 75+% Temperature variable	80	76	53	55
D	Out-of-doors Natural conditions Moisture and Temperature variable	67	56	38	29

they are somewhat similar to the eggs of *A. pomi*, which refuse to hatch if brought into a warm room earlier than 20–30 days before the normal outdoor hatching period.

In addition to the foregoing experiments on the response of the eggs to controlled moisture the author has made observations on the percentage of hatch of *A. avenæ* and *A. pomi* at New Brunswick for four seasons, 1917 to 1920. Table 4 gives observations for four seasons with the eggs of *A. avenæ*, showing the percentage of hatch and also the percentage of eggs with a split outer shell at the time hatching is rapidly taking place. The percentage of hatch varied considerably during the four years, yet these variations are probably due to the evaporation factors of the weather for the respective years. Unfortunately

no accurate record was made of the evaporating factors for each season, but if a comparison is made between the percentage of hatch and the rainfall for each year during the period when the eggs are most susceptible to moisture variations (10 to 14 days before hatching takes place rapidly) an interesting relationship exists. Table 3 shows the precipitation from March 5 to 31 for 1917 to 1920 and the H in each column indicates the date when rapid hatching occurred. In 1917 and

TABLE III.

Precipitation in inches for March 5–31, 1917, 1918, 1919 and 1920.

March	1917	1918	1919	1920
5	.09	.18	.07	1.17
6		.04		.71
7		.19	.26	
8	.50			
9	t	.02	.98	
10		.20	t	
11	.09			
12		.02	.10	.09
13				.98
14	.18	.84	.02	.03
15	.01	.03	.05	
16			.36	.07
17	.49		.06	.11
18	t		.22	
19				.12
20				.23
21	.17		H	
22				
23		H		
24	.42	.22		
25				
26				
27	.37	t	.55	t
28	.14	t	2.01	
29	t			.05H
30	H			
31	t			

t= trace of rain. H=eggs started to hatch rapidly.

1919 it rained more than half of the fourteen days previous to hatching and 50 to 65 per cent of the eggs hatched, while in 1918 and 1920 it only rained three and five days out of fourteen, and 30 to 40 per cent of the eggs hatched.

It is a well known fact that evaporating factors are usually low during rainy and cloudy weather and high when the sun shines. Furthermore, we have learned from the moisture control experiments that low evaporation (high moisture content of air) produces a large percentage of hatch, while high evaporation (low moisture content of air) produces a low percentage of hatch. From these observations we may conclude that the

TABLE IV.

Relationship between the amount of rainfall (moisture index) 14 days before hatching and percentage of hatch and split shells of eggs of *A. avenæ* at New Brunswick, N. J.

	1917	1918	1919	1920
Percentage of hatch	50%	30%	60–65%	38–40%
Percentage with split shells at hatching period	?	45–50	35–40	40?
General description of moisture condition of weather 14 days before hatching	Wet	Dry	Very Wet	Dry
Days of rain in 14	8	3	13	5
Date when eggs started to hatch rapidly	3–30	3–23	3–21	3–29

weather conditions for the respective years influenced the percentage of hatch. In other words, wet weather during the ten to fourteen days previous to hatching permits a greater number of eggs to hatch than dry weather during the same period.

Evaporating factors also appear to determine the rate of split in the outside coating of the eggs. Comparing the rate of split in the outer coats for the two extremely different seasons of 1918 and 1919 it will be noted that in the dry season of 1918, 45 to 50 per cent of the eggs had split their outer coats at the time of hatching and only 30 per cent eventually hatched. In other words, 15 to 20 per cent or more of the eggs with split outer coats never hatched. During the wet season of 1919 the reverse was true, only 35 to 40 per cent of the eggs showed a split outer coat at the time of hatching and 50 to 65 per cent

eventually hatched. In other words, 30 per cent more hatched than had split their outer coats at the hatching period. This condition is quite opposite to that of 1918. The author is of the opinion that evaporating factors have a decided influence on the outer coat. Conditions producing high evaporation probably make the outer shell brittle and easily broken by the growing embryo within, while low evaporating conditions tend to make the outer shell elastic, thus permitting greater expansion before it breaks. If the above is true then an early rupture of the outer coat is apt to be detrimental, for it exposes the permeable membrane to evaporating factors for a long period of time, while a delayed rupture in the outer coat is beneficial since the inner pervious membrane is exposed to evaporating factors for only a short period of time. Briefly stated, the above observations show that an early split of the outer coat, which is usually followed by a low percentage of hatch, is probably brought about by the existence of high evaporation during the susceptible period, while a delayed splitting, which in turn may be followed by a high percentage of hatch, is probably brought about by the existence of low evaporating factors during the susceptible period.

From the above experiments and observations made on the percentage of hatch in variable seasons, the author concludes that variations in the moisture content of the air largely determines the percentage of hatch of fertile eggs and probably influences the rate of split in the outside coat of the eggs. In other words, the moisture content of the air influences the evaporation of the water content of the eggs, determines the percentage of hatch and probably influences the rate of split in the outside coat.

TEMPERATURE.

No extensive experiments were made to determine the influence of temperature (as a factor in evaporation) upon the percentage of hatch. A few observations were made in respect to the influence of temperature on the rapidity of the splitting of the outer layer and the hatching of the eggs. During the past season 500 eggs of *A. avenæ* were collected on March 6, 14, 20 and 24, from each of four orchards located near Bridgeton, Glassboro, Riverton and Cranbury (See Map, Fig. 5). These orchards are located in the southern half of the state

and they are named in order from south to north. Table 5 shows the percentage of hatch and the percentage of eggs with split outer coats on the respective dates. Eggs collected from the southern point, Bridgeton, showed a development decidedly in advance of the eggs collected from the northern point, Cranbury, in all of the collections, while eggs collected from Glassboro and Riverton were intermediate in their stage of development. It is of interest to note that the stage of development in collections from the last named places were approximately the

TABLE V.

Influence of the geographical position (temperature) on the development of the eggs of *A. avenæ*. The percentage of eggs with a split outer shell and the percentage hatched in collections made on March 6, 14, 20 and 24, 1919, from four orchards (See Map) in the southern half of New Jersey.

Collected Observed	Percentage Split	Percentage Hatched	Percentage Split	Percentage Hatched	Percentage Split	Percentage Hatched	Percentage Split	Percentage Hatched
March 6	13	0.2 h	12.3	0.0 h	16	0.5 h	8.3	0.0 h
March 14	26	6 h	17	1 h	26	2 h	14	0.4 h
March 20	14	45 h	30	22 h	26	25 h	35	3.4 h
March 24	0.0	60 h	5	64 h	2	65 h	10	55 h
Location of Orchard	Bridgeton		Glassboro		Riverton		Cranbury	
Feet (approximate) above sea level	40		150		25		120	

h=Hatched eggs.

same. One would expect collections from Riverton to show a slower stage of development. Probably the location of the orchard has something to do with this. The orchard at Glassboro is approximately 100 ft. higher than the orchard at Riverton; furthermore the orchard at Riverton is within one mile of the Delaware river and the river at this point is subject to tide.

Low temperature may kill a small percentage of eggs. The dormant season of 1917–1918 was exceptionally cold, while the winter of 1918–1919 was mild and the temperature never went below 0° F. Eggs of *A. avenæ* brought into the laboratory during the last week in February of 1918 and placed in moist chambers (75–90 per cent moisture; room temperature 70° F.) showed 43–47 per cent hatch, while a similar experiment in 1919 showed 60–66 per cent hatch. This difference in

percentage of hatch might be accounted for by the low temperature of 1918; however, it is impossible to make a definite statement regarding this matter because the evaporating factors previous to the time when the eggs were brought into the laboratory may have been very different for the two seasons and this may have influenced the percentage of hatch. In other words it is possible that evaporating factors may have been much greater during the cold, dry season of 1917–1918 than during the mild wet winter of 1918–1919. This might account for the difference in the percentage of hatch in these experiments which were conducted under similar conditions during the respective season.

REFERENCES BY AUTHOR.

1917. Studies on the Morphology and Susceptibility of the Eggs of *Aphis avenæ* Fab., *Aphis pomi* DeG. and *Aphis sorbi* Kalt. Jour. of Econ. Ent., Vol. **10,** pages 556-560.

1918. Some Studies on the Eggs of Important Apple Plant Lice. New Jersey Agric. Expt. Sta., Bull. 332.

1919. Response of the Eggs of *Aphis avenæ* Fab. and *Aphis pomi* DeG. to Various Sprays, Particularly Concentrated Lime-sulfur and Substitutes, Season 1918-1919. Journ. Econ. Ent., Vol. 12, pages 363-386.

EXPLANATION OF PLATE XXXI.

All Figures of the eggs are typical of *Aphis avenæ* and *Aphis pomi.*

Fig. 1. Dorsal view of a normal dormant egg.

Fig. 2. Dorsal view of an egg showing an early stage in the usual type of splitting of the outer semi-transparent layer.

Fig. 3. Dorsal view of an egg showing an advanced stage in the usual type of splitting of the outer semi-transparent layer.

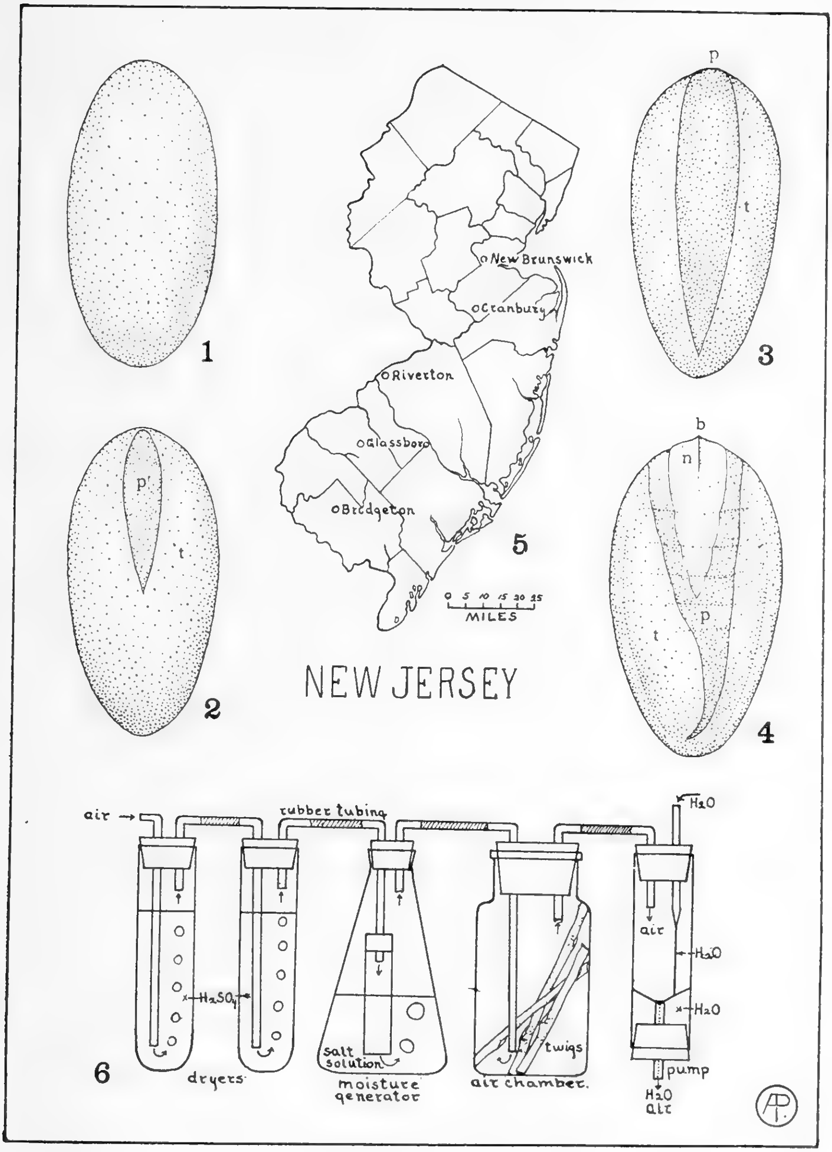
Fig. 4. Dorsal view of an egg showing an early stage in the emergence of the nymph. Note the egg burster on the head of the nymph along the meson and the cut pigmented inner layer.

Fig. 5. Map of New Jersey, showing location of orchards where eggs were collected for experiments recorded in Table 5.

Fig. 6. Diagramatic drawing of a moisture control equipment.

ABBREVIATIONS.

b. = Egg burster.
n. = Nymph.
p. = Inner pigmented layer (chorion).
t. = Outer semi-transparent layer.



Alvah Peterson

A NEW SUBFAMILY OF TANYDERID FLIES (DIPTERA).

By Charles P. Alexander,
Urbana, Ill.

The family Tanyderidæ, which includes the most generalized of the four recent families of crane-flies, has hitherto been represented by a single subfamily, the Tanyderinæ. This group has been further subdivided into a number of genera, varying from about six, in the opinion of Dr. Anton Handlirsch and others, to three, in the opinion of the writer. It is with great pleasure that a remarkable new genus and species is here made known, differing so strikingly from all members of the Tanyderinæ that a new group of co-ordinate value is required for its reception.

The distribution of the known recent species of the family, thirteen in number, may be listed.

Tanyderidæ (Macrochilidæ).

Subfamily Tanyderinæ.

Protoplasa Osten Sacken.

P. fitchii Osten Sacken, genotype. Eastern Nearctic Region.
P. vanduzeei Alexander. Western Nearctic Region.
P. vipio Osten Sacken. Western Nearctic Region.

Tanyderus Philippi.

T. annuliferus Hutton. Australasian Region.
T. forcipatus Osten Sacken. Australasian Region.
T. gloriosus Alexander. Southern Neotropical Region.
T. mirabilis de Meijere. Australasian Region.
T. ornatissimus Doleschall. Australasian Region.
T. patagonicus Alexander. Southern Neotropical Region.
T. pictus Philippi, genotype. Southern Neotropical Region.
T. beckeri Riedel. Southern Palaearctic Region. (Turkestan.)

Peringueyomyina Alexander.

P. barnardi Alexander, genotype. Southern Ethiopian Region.

Subfamily Bruchomyiinæ, new.

Bruchomyia, gen. n.

B. argentina, sp. n., genotype. Southern Neotropical Region.

The new genus *Bruchomyia* is based on material sent to the writer by Dr. Charles Bruch, to whom this remarkable fly is dedicated as an appreciation of the kind co-operation he has shown the writer in conducting a study of the Argentinian Tipuloidea.

Subfamily Bruchomyiinæ, subfam. n.

Small flies (Fig. 1), having the general appearance of a *Molophilus* (Tipulidæ); body and wings covered with long, dense hairs. Antennæ setaceous, with 30 segments, the last segment minute. Legs with the coxæ very long; tibiæ spurred; tarsal claws minute. Wings with Sc_1 lacking or apparently so; R and M forking far back near the wing-base, the forks being very deep; crossvein m lacking; anal vein subatrophied; anal angle of the wings lacking, this region fringed with very long hairs. Male hypopygium very small, concealed within the body; a single pleural appendage that is bifid.

The members of the Tanyderinæ are all large flies with the body not conspicuously hairy; antennæ with never more than 25 segments; m present; anal angle present and usually very prominent.

Genus **Bruchomyia,** gen. n.

Body (Fig. 1), very hairy, the head, thorax and abdomen provided with long, dense, erect hairs. Rostrum but slightly produced; palpi very large and conspicuous, very hairy, apparently four segmented, possibly five segmented. Antennæ (Fig. 4), 30 segmented; flagellar segments 28 in number, the last segment minute; scapal segments subequal in size, small, subglobular, the second with a circlet of short verticillate hairs; flagellum setaceous; first segment about as long as the following two taken together; flagellar segments 2 to about 20 subequal, elongate cylindrical; remaining segments gradually shortened, the last segment very tiny, button-like, the penultimate and antepenultimate oval (Fig. 5). Eyes very large, naked; ommatidia moderately large; eyes separated on the vertex (Fig. 3) only by a narrow strip that is from one-fourth to one-half the diameter of the basal scapal segment. Vertex with a dense crest of erect hairs. Legs (Fig. 6) comparatively stout; coxæ very long and slender, like a Mycetophilid; femora shorter than the tibiæ; tarsal segments gradually shortened from the first to the fifth; tibiæ provided with long, conspicuous bristles; tarsal segments with shorter, more flattened bristles; claws (Fig. 7) very small, subappressed to the end of the tarsus, the edges roughened, the rather long apex smooth; two slender tibial spurs. Wings with no anal angle; veins and margins with abundant long hairs that are especially elongate and conspicuous in the region of the anal angle; at the union of r–m with R_5 is a triangular chitinized area that is provided with conspicuous black hairs. Venation (Fig. 2): Sc_1 lacking, Sc_2 ending in R before the fork of R_{2+3}; Rs originating close to the wing-base, slightly proximad of the fork of M; Rs with four branches; M forking far back near the wing-base, the upper fork with two branches, the lower fork unbranched;

m lacking; *Cu* forked, the basal deflection of Cu_1 without macrotrichiæ; a single, semi-atrophied anal vein. Male hypopygium very small, densely covered by hairs; pleurites stout (Fig. 8), each near the apex on the inner face with a dense brush of stout black hairs; the single pleural appendage deeply bifid. Ninth sternite (Fig. 9) produced into a flattened pale appendage, deeply bifid at the apex, the margins provided with a few setæ. Penis-guard far within the body; a long, straight rod with the apex a little enlarged.

Genotype. *Bruchomyia argentina*, sp. n. (Southern Neotropical Region).

This remarkable new genus presents such a distinct appearance from all other members of the family that it is necessary to isolate the group. In its general appearance, the fly is strikingly like a large, very hairy *Molophilus*, the resemblance being heightened by the long, hairy wings, the long veins and deep forks, the concealed hypopygium, the elongate antennæ, and even the patch of dark hairs on the wing-disk, a character found in many species of *Molophilus*. It should be noted that although the venation is herein interpreted in accordance with the principles of the Comstock-Needham system, the distribution of the branches of media and cubitus render it highly probable that the contentions of Dr. Tillyard, that in the Diptera media is typically four branched, cubitus one branched, are correct. The portion of the vein labelled Cu_1 appears to be the posterior branch of the last forking of media, the basal deflection being without macrotrichiæ and very indistinct. This would be the *m-cu* crossvein of Tillyard. The semi-atrophied posterior branch of cubitus that was indicated by the writer as possibly being the atrophied first anal vein in Tipulidæ (The Crane-flies of New York, Cornell Memoir 25, pp. 867, 868; 1919) is here very weak, but indicated.

Nothing is known of the habits of these flies, but they were associated in collections with *Pectinotipula argentina* (Van der Wulp), *Holorusia jujuyensis* Alexander, *Brachypremna australis* Alexander, *Gonomyia* (*Leiponeura*) *bruchi* Alexander and other species of Tipulidæ and *Dixa argentina* Alexander. The genus must be regarded as the most generalized living Tipuloidean fly, this being amply demonstrated by the great number of antennal segments and wing-veins, the forking of all the longitudinal veins far back near the wing-base and the consequent very deep forks and other characters. The discovery of the immature stages would be a matter of extreme interest.

Bruchomyia argentina, sp. n.

General appearance much like a *Molophilus;* antennæ elongate, setaceous, 30-segmented; body and wings covered with long conspicuous hairs; *m* lacking; a patch of dark hairs at *r–m*.

Male.—Length, 4–4.5 mm.; wing, 4.3–5 mm.; antenna about 4 mm.

Frontal prolongation of the head short, brown, margined with dull yellow; palpi dark brown, conspicuous, covered with abundant long dark hairs. Antennæ setaceous, scapal segments dull yellow; flagellum pale brown, clothed with abundant subappressed dark hairs. Head grayish brown; lateral portions of the vertex with sparse black bristles, the median area with a high, dense crest of whitish hairs.

Pronotum brown, the lateral portions of the scutellum pale yellow. Mesonotum brown, the praescutum and scutum with three rather narrow gray stripes, the interspaces and a broad median strip provided with abundant black hairs; remainder of the mesonotum brown with abundant pale hairs. Pleura pale brownish yellow, the episternum more brownish, provided with long whitish hairs. Halteres stout, dark brown. Legs with the coxæ very long and slender, provided with hairs; trochanters comparatively small; remainder of the legs brown, covered with an abundant pale appressed pubescence and scattered erect bristles. Wings pale yellow, a little suffused with darker beneath the end of vein *Sc;* veins pale brown; veins and margin fringed with an abundant, long, dark-colored pubescence, longest at the region of the anal angle; a conspicuous patch of blackish brown hairs at *r–m* and the deflection of R_5. Venation, (Fig. 2).

Abdomen brownish testaceous, the tergites margined caudally with darker; surface of the abdomen covered with long whitish hairs.

Habitat: Argentina.

Holotype, ♂, La Granja, Alta Gracia, Province de Córdoba, April 1–8, 1920 (Charles Bruch).

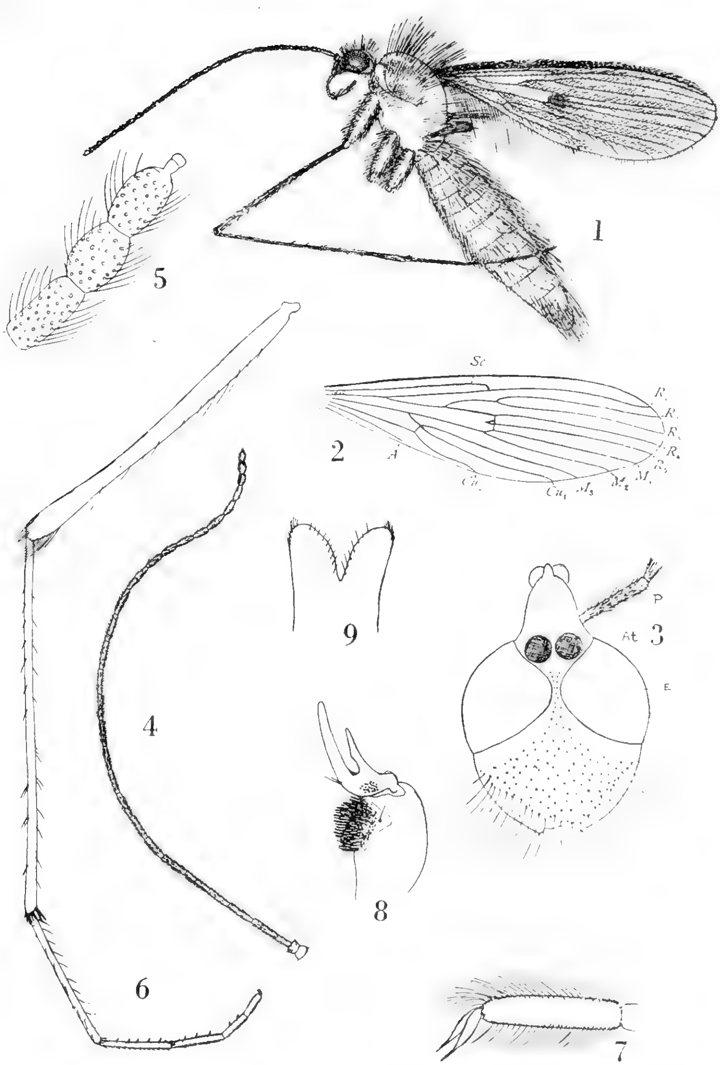
Paratopotypes, 3 ♂'s.

Type in the collection of the writer; paratype and other specimens in the collection of the La Plata Museum.

EXPLANATION OF PLATE XXXII.

Abbreviations—*Sc*=subcosta; *R*=radius; *M*=media; *Cu*=cubitus; *A*=anal vein; *At*=Antennal fossa; *E*=eye; *P*=palpus.

Fig. 1. Sketch of the entire fly of *Bruchomyia argentina,* to show the general appearance.
Fig. 2. Wing-venation; the hairy covering has been removed to show the venation more clearly.
Fig. 3. Head; dorsal aspect.
Fig. 4. Antenna.
Fig. 5. Four terminal segments of antenna.
Fig. 6. Leg.
Fig. 7. Last tarsal segment and claws.
Fig. 8. Pleurite of male hypopygium.
Fig. 9. Appendage of ninth sternite of male hypopygium.



Charles P. Alexander

THE CORRECT NAME FOR THE DIPTEROUS GENUS DICRANIA.

By Prof. M. Bezzi, Turin, Italy.

In a paper entitled "Descriptions of Horseflies from Middle America," (Ohio Journal Science, Columbus, XX, No. 6, April, 1920, p. 185-192), Prof. J. S. Hine has proposed the new name Stichocera for Dicrania Macquart and for Dicranomyia Hunter, both of which have been used for the same genus (genotype *Pangonia cervus* Wiedemann) and are preoccupied.

But as long ago as in 1913 two other names were proposed for the same purpose and for the same genotype. These names are: (1) *Elaphella*, proposed by the present writer in a paper entitled "Einige alte und neue Namen bei den Dipteren" (Societas Entomologica, XXVIII, No. 13, July, 1913, p. 56); and (2) *Allodicrania*, proposed by Doctor G. Enderlein in the paper "Dipterologische Studien III," (Zool. Anz., XLII, No. 6, July 18, 1913, p. 253).

As the name proposed by me appeared in print thirteen days before that proposed by Doctor Enderlein, it must be retained. We have thus:

Family Tabanidae.

Sub-Family Pangoniinæ.

Elaphella Bezzi, 1913. Genotype: *Pangonia cervus* Wiedemann, 1828.

Syn. *Dicrania* Macquart, Suite a Buffon, I, 1834, p. 195, (nec Dicrania Lep. Serv. 1825, Coleoptera).

Syn. *Dicranomyia* Hunter, Trans. Am. Ent. Soc. XXXVII, 1901, p. 135, (nec Dicranomyia Stephens, 1829, Diptera).

Syn. *Allodicrania* Enderlein, Zool. Anz. XLII, 1913, p. 253.

Syn. *Stichocera* Hine, Ohio Journal Science, XX, 1920, p. 192.

The incorrect name, Dicrania, has been used by Giglio Tos, Ricardo and Lutz in their works; and the probably incorrect Dicranomyia has been employed by Doctor Kertesz in his catalogues, and by Surcouf et Gonzalez-Rincones in the work on the biting Diptera from Venezuela.

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